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COMMITTEE ON PAPERS AND PUBLICATIONS:

J. F. GEISLER,
A. C. HALE,
A. A. BRENEMAN, Editor.

ABSTRACTORS:

J. F. GEISLER, WILLIAM RUPP,
L. H. FRIEDBURG.

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(See page 3 of Cover.)

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The Journal of the American Chemical Society appears monthly, except during July and August. It will contain all papers read before the Society, as well as abstracts from American and Foreign Journals, and a list of American Patents relating to Chemical Industries.

The Price of Subscription is $5.00 per year, in advance.

The Meeting Room and Library of the Society are in University Building, Washington Square, New York.

The Regular Monthly Meeting is held on the first Friday of every month, at 8 P. M.

Corresponding Secretary:

A. C. HALE, 551 Putnam Ave., Brooklyn, N. Y.

Treasurer:

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Back numbers of the Journal are sold to Members at $3.00, to others at $5.00, per volume. Apply to the Librarian

WILLIAM RUPP, 97 Water St., New York.

The Committee on Papers and Publications respectfully call attention to the resolutions of the Society, requiring that papers be submitted to the Committee before being read.

Authors will be furnished, gratis, with 20 reprints of each article published in the Journal, if application for the same be made when the article is sent.

Members are requested to give notice of any change of address, or failure in the delivery of the Journal. All communications relating to the Journal should be addressed to the Editor.

A. A. BRENEMAN, 97 Water St., New York.

THE NEWPORT MEETING.

In accordance with the provisions of the revised constitution of the American Chemical Society (Art. VII, Section 2), and in pursuance of a resolution of the Society passed at the regular meeting, June 6, 1890, the Board of Directors, on July 22, called a general meeting of the Society at Newport, R. I., Aug. 6 and 7, 1890. Owing to the unavoidable shortness of the notice given, it was feared that no adequate attendance of chemists could be secured, and the meeting was regarded more as an introduction to a series of general meetings to be held hereafter than as a test of the favor which might be expected for the new plan from the chemists of the country.

The meeting has been a great success, however, and it was regarded by those present as fully equal, both in general interest and in scientific gain, to any gathering of chemists ever held in America.

Over forty chemists attended the meeting, and, together with friends who accompanied them and citizens of Newport who took part in the entertainment of the visitors, made the occasion an attractive one in its social as well as in its professional aspect.

Seventeen papers were read and these, with the discussions upon them and the general business of the meeting, fully occupied the morning sessions. A list of these papers is given in the programme, page 252. The time of the meeting was so divided as to allow the hours from 10 A. M. to 1 P. M. to be given to the reading of papers, business, etc. At 1 P. M. a luncheon, provided each day through the kindness of the local committee, was served in a room adjoining the hall.

At 2 P. M. the visitors were taken upon steam launches, provided by the local committee to points of interests about Newport harbor and the afternoon spent in sailing each day was a pleasant relaxation after the work of the morning. Wednesday evening was

given up to social intercourse amongst the visitors, and on Thursday evening the reception given by Prof. J. P. Cooke was a fitting conclusion to the long series of courtesies offered by the local committee.

During the meeting a collection of chemical apparatus was exhibited in a room adjoining the hall. It is hoped that at general meetings in future this feature will be much more fully developed. Invitations were sent to many dealers in chemical apparatus, but the notice of the meeting was too short for proper efforts in this direction.

The meeting was opened Wednesday, August 6th, at 10 A. M. (See minutes of meeting.)

WEDNESDAY AFTERNOON.

Members and invited guests met at the Ferry at 2:30, and were taken on a government launch to the United States Naval Torpedo Station, situated on an island in the harbor opposite Newport, where they were met by Commander T. F. Jewell, U. S. N., in charge of the Torpedo Station, through whose courtesy the museum, laboratory and shops of the station were opened to the party. The historical collection of torpedoes and models was shown, including torpedoes of modern construction, ready for use. At the laboratory Prof. C. E. Munroe explained the action of a number of high explosives and showed the results of experiments in crushing and rupturing of metallic plates. Afterwards several submarine torpedoes were exploded in the harbor, and a series of tests with high explosives was made. Discs of compressed gun cotton, dynamite, etc., were detonated upon plates of wrought iron; compressed gun cotton was partly burned in an open fire and then exploded by detonation. A naked disc of gun cotton bearing the impressed letters A. C. S. was detonated upon an iron plate, and the letters were shown to be clearly impressed upon the metal afterwards. A "necklace" of discs of gun cotton was hung about the top of a wooden post twelve inches in cross section and the timber was cut off squarely by detonation of the cotton.

At 4 o'clock the party were taken to the United States Naval Training Station, also located on an island in the harbor, where,

through the courtesy of Capt. Stanton, U. S. N., commanding, they witnessed a parade of the battalion of boys belonging to the station. Afterward they were entertained at the officers' quarters, and, before leaving, were shown the barracks and drill room under the guidance of Surgeon C. A. Siegfried, U. S. N. The return to Newport was made at 6 P. M.

THURSDAY, AUG. 7.

MORNING.

The meeting was called to order at 10 o'clock. (See minutes of meeting.)

AFTERNOON.

2 o'Clock.—Through the courtesy of the local committee an excursion in Newport harbor was provided. The larger portion of the visitors were taken on a government launch under the guidance of Major Livermore, and after sailing about the harbor, were landed at Fort Adams at 4 P. M. A smaller party took passage on the Herreshoff torpedo boat Stiletto, which was kindly placed at their service by Commander Jewell, and made a tour of about thirty miles around the island of Conanicut. The great speed of the little boat and the perfection of her machinery called forth much enthusiastic comment. The Stiletto reached Fort Adams before four o'clock and the united party of visitors were taken to the artillery parade ground, where, through the courtesy of Col. John Mendenhall, commanding, they spent an hour in watching the evolutions of a battery of artillery, consisting of four field pieces, with its full complement of men and horses. After a number of rounds had been fired by the battery the guests were permitted to inspect the mechanism of the breech loading guns. Returning to the boats, a stop was made to examine the large guns of the Fort.

The party returned to Newport at 6 o'clock.

The reception given to the chemists attending the meeting by Prof. J. P. Cooke, at his home, cor. Gibbs avenue and Beach street, Newport, was very fully attended. Many specimens of meteorites from the collection of Prof. Cooke were shown during the evening.

The following is a list of chemists who attended the meeting, as taken from the register kept at the office of Mr. A. O. D. Taylor, of the local committee :

Prof. John H. Appleton, Brown University, Providence, R. I.
Elias H. Bartley, M. D., Brooklyn, N. Y.
Marcus Benjamin, Ph. D., New York.
William B. Bentley.
Prof. A. A. Breneman, New York.
Edwin C. Calder, Providence, R. I.
Prof. C. F. Chandler, Columbia College, New York.
Prof. F. W. Clarke, chief chemist, U. S. Geological Survey, Washington, D. C.
Prof. Josiah P. Cooke, Harvard University, Cambridge, Mass.
William D. Crumbie, U. S. Laboratory, New York.
Prof. A. E. Dolbear, Tuft's College, Medford, Mass.
Prof. C. A. Doremus, City College, New York.
Dr. L. H. Friedburg, City College, New York.
Dr. Wolcott Gibbs, Harvard University, Cambridge, Mass.
Martin L. Griffin, Holyoke, Mass.
Prof. Albert C. Hale, Brooklyn, N. Y.
Dr. A. P. Hallock, New York.
Dr. Walter H. Kent, Board of Health, Brooklyn, N. Y.
Major W. R. Livermore, U. S. A., Newport, R. I.
Dr. Morris Loeb, Clark University, Worcester, Mass.
Prof. W. M. McMurtrie, New York.
Prof. E. W. Morley, Western Reserve University, Cleveland, Ohio.
Prof. Charles E. Munroe, U. S. Naval Torpedo Station, Newport, R. I.
E. B. Newbury, Cornell University, Ithaca, New York.
Lyman C. Newell, Pawtucket, R. I.
C. F. Parker, U. S. A., Newport, R. I.
G. W. Patterson, U. S. Torpedo Station, Newport, R. I.
Charles M. Perry, Providence, R. I.
Dr. C. A. Pitkin, Thayer Academy, South Braintree, Mass.
Lucius Pitkin, Ph. B., New York.
William R. Potter, Providence, R. I.
Frederic Read, New York.

William Rupp, New York.
Prof. A. H. Sabine, Long Island City, New York.
Edward Sherer, U. S. Laboratory, New York.
C. A. Siegfried, Surgeon U. S. N., Newport, R. I.
Herbert E. Smith, New Haven, Conn.
Frank E. Thompson, Head Master Rogers High School, Newport, R. I.
J. H. Wainwright, Ph. B., U. S. Laboratory, New York.
Lieut. Willoughby Walke, 2d U. S. Artillery, Fort Monroe, Va.
Prof. Elwyn Waller, Columbia College, New York.
Arthur W. Wellington, Newport, R. I.
Dr. H. J. Wheeler, Experiment Station, Kingston, R. I.

LOCAL COMMITTEE.

Prof. Charles E. Munroe, *Chairman.*
Dr. J. P. Cooke.
Dr. Wolcott Gibbs.
Major T. K. Gibbs.
Commander T. F. Jewell, U. S. N.
Major W. R. Livermore, Eng. Corps, U. S. A.
Dr. C. A. Siegfried, Surgeon, U. S. N.
Dr. T. A. Kenefick.
A. O'D. Taylor, Esq., Secretary Newport Natural History Society.
C. A. Pitkin, Ph. D.
F. E. Thompson, Head Master Rogers High School.
Lt. C. DeW. Wilcox, 2d Art., U. S. A.
F. Bradley, D. M. D.
G. W. Patterson, Esq.

COMMITTEE OF ARRANGEMENTS.

Prof. A. A. Breneman, *Chairman.*
Prof. C. F. Chandler.
William Rupp.
C. F. McKenna.
J. F. Geisler.

MINUTES OF THE FIRST GENERAL MEETING OF THE AMERICAN CHEMICAL SOCIETY, HELD AT MASONIC HALL, NEWPORT, R. I.,

AUGUST 6 AND 7, 1890.

FIRST DAY—AUGUST 6.

The meeting was called to order at 10.15 A.M. by Prof. Charles F. Chandler, chairman. Prof. Albert C. Hale was appointed secretary.

An address of welcome in behalf of the citizens of Newport was then presented by Col. John Hare Powel, Ex-Mayor of Newport, and a descendant of Dr. Robert Hare of Philadelphia.

In the response by the Chairman, Prof. Chandler, a brief resumé of the organization and history of the Society was given, and special reference was made to the recent revision of the Constitution, under which this first general meeting was called.

Letters of regret were then read from the following members, who were unable to attend the meeting, viz.:

President, H. B. Nason, Troy, N. Y.; Dr. F. A. Genth, Philadelphia; Dr. T. Sterry Hunt, New York; Prof. Henry Morton, Hoboken.

The reading of papers being in order, the following papers were presented:

"Determination of the Strength of various High Explosives."—Willoughby Walke.

"The Volumetric Composition of Water."—E. W. Morley.

"On Carbon as an Impurity Affecting the Determination of the Atomic Weight of Hydrogen."—E. W. Morley.

"A New Form of Air Thermometer for Technical Uses."—A. H. Sabine.

"A New Apparatus and an Improved Method for the Estimation of Urea."—E. H. Bartley.

"On Resins."—L. H. Friedburg.

The meeting was adjourned at 12.50.

SECOND DAY—AUGUST 7.

The meeting was called to order by the Chairman, Prof. C. F. Chandler at 10.15 A.M.

An announcement was made by Prof. C. E. Munroe regarding the afternoon excursion on the U. S. Torpedo boat "Stiletto."

An invitation was given the members and guests of the Society, by Prof. Josiah P. Cooke, to attend an informal reception at his home, Gibbs ave. and Beach street, Thursday evening between 7 and 9 o'clock.

On motion of Prof. A. A. Breneman, Chairman of the Committee of Arrangements, the following votes of thanks were extended:

I.—To the Members of the Local Committee.

II.—To Col. John Mendenhall, U. S. A., commanding Fort Adams,
Capt. Oscar F. Stanton, U. S. N., commanding U. S. Naval Training Station,
Com. T. F. Jewell, U. S. N., commanding Torpedo Station,
Major W. R. Livermore, Eng. Corps, U. S. A.

III.—To the Newport Natural History Society for the offer of its rooms for the meeting.

IV.—To the Citizens of Newport for their kindness and courtesy.

The Chairman then announced an informal discussion regarding the more general organization of chemists in America. On motion of Dr. Waller, it was voted that all chemists present be invited to present their views freely, and have all privileges of discussion and voting upon the subject.

After some introductory remarks by Prof. Chandler, Prof. Clarke opened the discussion by presenting a brief history of the new movement for a proposed "Continental" Society. He was followed by Dr. Wolcott Gibbs, Dr. J. P. Cooke, Maj. Livermore, Dr. C. A. Doremus, Dr. Morris Loeb, Prof. A. H. Sabine, Prof. A. A. Breneman, Prof. Albert C. Hale, Dr. Waller, and others. Dr. Waller moved that the Chair appoint three members of the American Chemical Society to represent that society at a conference of representatives of various societies and chemists in this country, the time and place of said conference to be left indefinite. This motion was carried. Prof. McMurtrie moved that details be left with the chair. Carried.

The following names were then read as applicants for membership:

Dr. C. E. Pellew, New York.

Dr. H. J. Wheeler, Kingston, R. I.

Dr. J. H. Washburn, Kingston, R. I.

Prof. Chas. E. Brewer, Wake Forest College, Wake Forest, N. C.

Dr. P. T. Austen, Rutgers College, New Brunswick, N. J.

Dr. Edward S. Wood, Harvard Med. School, Cambridge, Mass.

Dr. Geo. Archbold, U. S. Navy Yard, Washington, D. C.

Dr. Chas. G. Curtman, 3718 N. 9th street, St. Louis, Mo.

Dr. Stephen H. Emmens, Emmensite Explosive and Ammunition Co., Emmens, Pa.

Major W. R. Livermore, Eng. Corps, U. S. A., Newport, R. I.

Chas. A. Pitkin, A. M., Ph. D., Thayer Academy, So. Braintree, Mass.

Louis H. Laudy, Ph. D., School of Mines, Columbia College, N. Y.

F. E. Thompson, Roger's High School, Newport, R. I.

George W. Patterson, Torpedo Station, Newport, R. I.

The reading of papers being in order, the following were presented:

*"On the Perissad Law."—W. R. Livermore.

"On the Relative Intensity of Chemical Force."—L. H. Friedburg.

"On Bütschli's Experimental Imitation of Protoplasm."—C. A. Siegfried.

*"Notes on Water Analysis by the Ammonia Method with some new Apparatus."—A. A. Breneman.

†"On the Chemical Work of the United States Geological Survey."—F. W. Clarke.

†"On Grass Oils."—F. D. Dodge.

†"On the Action of the Nitrils on Organic Acids."—C. E. Colby and F. D. Dodge.

‡"On the Influence Method as a Test for Explosives."—C. E. Munroe.

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*To appear in the October number.

†These papers were merely notes in advance of publications from articles that had already been given to other journals.

‡Withheld temporarily from publication for official purposes.

"On the Use of the Gooch Crucible as a Silver Voltameter."—Morris Loeb.

"On the Extraction of Indigotin from Commercial Indigo."—T. A. Morgan.

"On the Uses of Fluorine for the Softening of Hard Water."—C. A. Doremus.

The meeting was then adjourned.

ALBERT C. HALE, Secretary.

ON THE DETERMINATION OF THE STRENGTH OF VARIOUS HIGH EXPLOSIVES.

By Willoughby Walke, Lieut. 2d U. S. Artillery, Instructor in Charge U. S. Artillery School Laboratory.

This paper was suggested during a series of experiments undertaken some months ago for the purpose of reconciling apparently great inconsistencies with regard to the relative strengths claimed for various newly invented or patented explosives. No originality is claimed for the methods pursued, but it is thought that a summary of the results obtained may prove of value. The great facility with which an explosive can be invented, and the attraction that work of this character possesses for investigators, both great and small, may explain, in a measure, the annual outpour of so called new explosives. Presuming upon the ignorance or lack of scientific knowledge on the part of the practical miner, the most extravagant and misleading claims are made for the majority of these powers, not the least significant of which is that all are equally as strong as, and many of them much more powerful than liquid nitroglycerine. It was in order to verify or disprove this particular claim that the following experiments were undertaken, especially as strenuous efforts have been made by some of the inventors to have their powders adopted for military and naval purposes.

The first step in the work at hand was to provide apparatus for accurately registering the effects of the various explosives, and on account of the limited facilities at my disposal I had little latitude of choice.

Several methods have been devised for the purpose of testing the strength of explosives, but as yet none can be said to give perfect satisfaction. All of them are approximations, nor do the in-

ventors claim more for them. Even the *crusher* used by Berthelot in his elaborate investigations in this direction gave only approximate results, as demonstrated by M. M. Sarau and Vieille.

The majority of the methods pursued seek to determine merely the comparative strength of the explosives, some one explosive being selected as the standard with which all others are compared. It still remains to institute an accurate, absolute scale, by which the strength of explosives may be measured.

After due consideration, it was decided to use the Quinan pressure gauge, both on account of the degree of accuracy with which it registers the pressures developed by the explosives, or rather "by the gases resulting from the decomposition of the explosives," and because of the ease with which the apparatus is manipulated.

The instrument used in the following experiments consists of a heavy block of wood, upon which is bolted a cast iron block or base. In this base are inserted four wrought iron guides or standards, set around the circumference of a four inch circle. A steel plate is let into the iron block flush with its upper surface. A ring holds the guides in place at the top, their ends being reduced to screwbolts passing through the ring, which is held down by nuts.

The piston, which rests upon the plug or cylinder of lead (to be compressed) is a cylinder of tempered steel, four inches in diameter and five inches in length. It is turned away at the sides to lighten it as much as possible. It moves freely between the guides. In the top of the piston is a parabola-shaped cavity to hold the charge of explosive. The weight of the piston is twelve and one-quarter pounds. The shot, made of tempered steel, is four inches in diameter and ten inches in length, weighing thirty-four and one-half pounds. It is bored through its axis to receive a capped fuse.

To operate the instrument, a plug or cylinder of lead is placed upon the steel plate within the guides. The piston is put down gently upon it and the charge of explosive placed in the cavity. The shot is next lowered gently upon the piston and the capped fuse pushed down through the hole in the shot. The fuse being lighted, the charge is exploded when the fire reaches the cap, throwing out the shot and compressing the lead plug. The accu-

racy of the test is based upon the assumption that the lead plugs shall be of uniform density and homogeneous in structure. The form of plug adopted was a cylinder, one inch in diameter and one inch in length. In regard to the kind of plug, the choice lay between plugs cast in molds and plugs cut from a solid bar which could be obtained of the desired dimensions in the factories. This bar, though not made of perfectly pure lead, is manufactured from large masses of metal at a high temperature, is very dense and can be obtained in lengths of fifty feet.

It was decided that the desired uniformity would be more likely to obtain in this product than in plugs cast one at a time from small masses of metal. Having prepared plugs of both kinds, the next point was to test their relative merits for the object in view. The nature of this test was fixed by an additional and independent consideration. It should be borne in mind that, while being compressed by the explosion in the pressure gauge, the density of the plug as well as the lead surface opposed to the piston continually increases.

It is evident, therefore, that the amount of compression shown by the plug is not a direct measure of the strength of the explosive.

For example: if one powder exploded in the pressure gauge compresses a plug $\frac{250}{1000}$ths of an inch, and another powder compresses a plug $\frac{500}{1000}$ths of an inch, the latter powder would be twice as strong as the former if the compressions were direct measures of their relative strengths, but from what has preceded, it is evident that the second is much more than twice as strong as the first powder, and the difficulty arises in determining the relation existing between the two.

As a practical measure of the strength, Mr. W. R. Quinan, the inventor of the gauge, to whom I am greatly indebted for valuable information on the subject, assumed that it was proportional to the work performed in reducing the height of the lead cylinder. To get an expression for the work, Mr. Quinan determined, by means of a simple apparatus, the number of foot pounds required to produce the different amounts of compression, and graphically represented the relations existing between the plug compressions and foot pounds by means of a diagram, which was constructed,

using the compressions as the ordinates, and the foot pounds as the abscissas of a curve. The extreme co-ordinates were fixed by nitroglycerine.

As it was impossible to secure one of these diagrams, and as I had not time to undertake the experiments necessary to construct one in time for use for the experiments at hand, it is unnecessary to enter at a greater length into the details of this portion of the subject, especially as the results recorded are referred directly to nitroglycerine as a standard, with no reference to the absolute strengths of the various explosives. While the results registered by the pressure gauge are very reliable as comparative measures for high explosives, they are not equally true and accurate for the lower class. "A triple charge of good black blasting powder, fixed with a fuse, will produce a scarcely perceptible effect on the plug, and yet we know that this powder is capable of great work under certain conditions.

"We may suppose, without an error affecting our principle, that in firing twenty-four grains, or 1.555 grammes, of high powder, the product of the amount of gas, multiplied by the temperature of the gases, gives a number equal to the product of the corresponding elements in the explosion of thrice the charge of black powder. But in one experiment we get a compression which is almost infinitely greater than in the other; for in the last we get a result too small to be measured. It is because the third factor in one formula for explosive effect, *time*, bears a similar but inverse ratio in the two cases: in the first being inconceivably short, and in the second case a sensible interval.

"In the explosion of the black powder, the force, though great, is developed so gradually that at no one instant is sufficient inertia developed in the shot to produce a sensible compression of the lead."

(Report on Vigorit Powder, by Wm. R. Quinan.)

Having decided the means of measurement and secured and tested the lead cylinders, the next step was to select the standard explosive with which to compare all others under examination. It has been shown that the pressure gauge is not an accurate test for the lower explosives, and, as nearly all of the explosives

to be tested belonged to the class of high explosives, nitroglycerine was selected as the standard. The lot of nitroglycerine to be used for this purpose was made some months beforehand, so as to allow it to "clear up" and attain its normal condition, as previous experiments had shown that, during the process of "clearing," nitroglycerine varied in strength from day to day.

The nitroglycerine prepared for use as the standard was very carefully made, the acids and glycerine being tested beforehand, on November 19, 1889, after the method originally pursued at the U. S. Naval Torpedo Station as follows:

HNO_3 (Sp. Gr. 1.50)----------1 part.
H_2SO_4 (Sp. Gr. 1.84)----------2 parts.

As soon as this acid mixture had cooled

Glycerine (puriss. anhyd.)----------1 part

was gradually introduced with constant agitation into

Acid mixture----------6 parts.

Upon total conversion of the glycerine into the nitric ether, the latter was thoroughly freed from all traces of acid, and then poured into a large glass jar, covered with distilled water, and the jar loosely corked.

In about six weeks, the opaque appearance of the oily fluid had entirely disappeared, and it had assumed the normal appearance of pure glycerine. It was carefully tested from time to time and was found to be entirely satisfactory.

The uniformity of the lead cylinders was tested by carefully weighing and testing several taken at random, and all above or below a certain standard, as well as those showing any defects were rejected.

The mean of several weights and measurements gave

Weight of cylinder----------145.729 grm.
Length " " ----------1″.000 2.540 cm.
Diameter " " ----------1″.000 2.540 cm.

In the subsequent work, the difference in weight of the several cylinders did not exceed 10 or 15 mg., while the standard length and diameter of 1″.000 2.540 cm. was absolutely maintained.

One other point was determined beforehand, namely, the relative strength of the caps to be used to explode the several charges. This step was deemed advisable lest it should be found necessary to use caps of different strength for the different explosives. The uniform charge of 24 grs., or 1.555 grm. was used in the gauge for all explosives.

RECORD OF EXPERIMENTS.

I. *Nitroglycerine,* used as the standard of comparison.

Mode of preparation:

HNO_3 (Sp. Gr. 1.50)..... 1 part.
H_2SO_4 (Sp. Gr. 1.84)..... 2 parts.

and of this

Acid Mixture..... 6 parts.
Glycerine (puriss. anh.)..... 1 part.

Number of Experiment.	Length of Cylinder before Compression.	Length of Cylinder after Compression.	Amount of Compression.
	2.540 c. m.		
1	1″.000	0″.452	0″.548
2	1″.000	0″.450	0″.550
3	1″.000	0″.445	0″.555
		Mean.....	0″.551

II. *Explosive Gelatine.*

Mode of preparation:

Nitroglycerine..... 92 parts.
Camphor..... 2 parts.
Gun-cotton (soluble)..... 6 parts.

Note.—The nitroglycerine used in the preparation of this sample of explosive gelatine was made according to the French method pursued at Vonges. Both the nitroglycerine and explosive gelatine were made and tested on the same day.

Number of Experiment.	Length of Cylinder before Compression.	Length of Cylinder after Compression.	Amount of Compression.
4	1″.000	0″.435	0″.565
5	1″.000	0″.410	0″.590
6	1″.000	0″.399	0″.601
		Mean.....	0″.585

III. *Hellhoffite.*

Mode of preparation:

HNO_3 (Sp. Gr. 1.50) ..... 53 parts.
Dinitrobenzole ..... 47 parts.
($C_6H_4(NO_2)_2$ added to saturation.)

Number of Experiment.	Length of Cylinder before Compression.	Length of Cylinder after Compression.	Amount of Compression.
7	1″.000	0″.415	0″.585
8	1″.000	0″.415	0″.585
9	1″.000	0″.415	0″.585
		Mean	0″.585

IV. *Nobel's Smokeless Powder.*

Mode of preparation:

Nitroglycerine ..... 50 parts.
Camphor ..... 5 parts.
Benzole ..... 100 parts.
Gun-cotton (soluble) ..... 25 parts.

The camphor was dissolved in the nitroglycerine and the benzole added.

Gun-cotton was added and stirred until the whole became gelatinized. The benzole was next evaporated on a water bath, the mass rolled out into a sheet and finally cut up into small cubes.

Number of Experiment.	Length of Cylinder before Compression.	Length of Cylinder after Compression.	Amount of Compression.
10	1″.000	0″.500	0″.500
11	1″.000	0″.486	0″.514
12	1″.000	0″.485	0″.515
		Mean	0″.509

V. *Nitroglycerine.*

Mode of preparation:

According to U. S. Naval Torpedo Station process, and tested immediately upon completion.

Number of Experiment.	Length of Cylinder before Compression.	Length of Cylinder after Compression.	Amount of Compression.
13	1″.000	0″.491	0″.509
14	1″.000	0″.491	0″.509
15	1″.000	0″.491	0″.509
		Mean	0″.509

VI. *Explosive Gelatine.*

Mode of preparation :

Same as in II., Expts. 4, 5 and 6, except that the nitroglycerine was taken from that used in V., Expts. 13, 14 and 15.

Number of Experiment.	Length of Cylinder before Compression.	Length of Cylinder after Compression.	Amount of Compression.
16	1″.000	0″.520	0″.480
17	1″.000	0″.504	0″.496
18	1″.000	0″.506	0″.494
		Mean	0″.490

VII. *Gun-cotton.*

Mode of preparation :

Sample or charge was taken from a disk of U. S. Naval Torpedo Station, Lot No. 100, 1889.

Number of Experiment.	Length of Cylinder before Compression.	Length of Cylinder after Compression.	Amount of Compression.
19	1″.000	0″.543	0″.457
20	1″.000	0″.543	0″.457
21	1″.000	0″.540	0″.460
		Mean	0″.458

VIII. *Gun-cotton.*

Mode of preparation :

Charge taken from a disk of Stowmarket cotton made in 1885.

Number of Experiment.	Length of Cylinder before Compression.	Length of Cylinder after Compression.	Amount of Compression.
22	1″.000	0″.545	0″.455
23	1″.000	0″.541	0″.459
24	1″.000	0″.541	0″.459
		Mean	0″.458

IX. *Nitroglycerine.*

Mode of preparation :

According to the process pursued at Vonges as follows :

The following mixtures were made and allowed to cool :

HNO_3 (Sp. Gr. 1.50)..... 1 part.

H_2SO_4 (Sp. Gr. 1.84)..... 1 part.

and

H_2SO_4 (Sp. Gr. 1.84)..... 3.2 parts.

Glycerine (puriss. anhyd.)..... 1.0 part.

As soon as cool, 4.2 parts of the sulpho-glycerol was added to 5.6 parts of the acid mixture, the vessel was loosely covered, and the reaction allowed to proceed under a hood for 12 hours.

The nitroglycerine was then separated from the acids and thoroughly washed.

Number of Experiment.	Length of Cylinder before Compression.	Length of Cylinder after Compression.	Amount of Compression.
25	1″.000	0″.550	0″.450
26	1″.000	0″.548	0″.452
27	1″.000	0″.549	0″.451
		Mean	0″.451

X. *Gun-cotton.*

Mode of preparation :

This explosive was made in the laboratory according to the U. S. Torpedo Station process, but no effort was made to pulp, poach or press it. It was simply pure trinitrocellulose.

Number of Experiment.	Length of Cylinder before Compression.	Length of Cylinder after Compression.	Amount of Compression.
28	1″.000	0″.552	0″.448
29	1″.000	0″.552	0″.448
30	1″.000	0″.552	0″.448
		Mean	0″.448

XI. *Dynamite No. 1.*

Mode of preparation :

Nitroglycerine (same as V.) ..... 6 parts.
Kieselguhr ..... 2 parts.
Mg CO_3 ..... 0.14 parts.

Number of Experiment.	Length of Cylinder before Compression.	Length of Cylinder after Compression.	Amount of Compression.
31	1″.000	0″.552	0″.448
32	1″.000	0″.552	0″.448
33	1″.000	0″.552	0″.448
		Mean	0″.448

XII. *Dynamite de Trauzl.*

Mode of preparation :

Nitroglycerine (same as V.) ..... 75 parts.
Gun-cotton ..... 25 parts.
Charcoal ..... 2 parts.

The gun-cotton and charcoal were very finely divided before being added to the nitroglycerine.

Number of Experiment.	Length of Cylinder before Compression.	Length of Cylinder after Compression.	Amount of Compression.
34	1″.000	0″.563	0″.437
35	1″.000	0″.563	0″.437
36	1″.000	0″.563	0″.437
		Mean	0″.437

XIII. *Emmensite.*

Mode of preparation:

"Emmens Acid" was first made by dissolving commercial picric acid, at a gentle heat, in nitric acid (Sp. Gr. 1.50) and evaporating. The explosive itself was made by fusing together in a paraffin bath

Emmens Acid ..... 5 parts.
$NH_4 (NO_3)$ ..... 5 parts.

And then incorporating

Picric Acid ..... 6 parts.

Number of Experiment.	Length of Cylinder before Compression.	Length of Cylinder after Compression.	Amount of Compression.
37	1″.000	0″.571	0″.429
38	1″.000	0″.571	0″.429
39	1″.000	0″.571	0″.429
		Mean	0″.429

XIV. *Amide Powder.*

Mode of preparation:

KNO_3 ..... 101 parts.
$NH_4 (NO_3)$ ..... 80 parts.
Charcoal ..... 40 parts.

Number of Experiment.	Length of Cylinder before Compression.	Length of Cylinder after Compression.	Amount of Compression.
40	1″.000	0″.614	0″.386
41	1″.000	0″.615	0″.385
42	1″.000	0″.616	0″.384
		Mean	0″.385

XV. *Oxonite.*

Mode of preparation :

HNO_3 (Sp. Gr. 1.50)..... 54 parts.
Picric Acid..... 46 parts.

[$C_6H_3O(NO_2)_3$ added to saturation.]

Number of Experiment.	Length of Cylinder before Compression.	Length of Cylinder after Compression.	Amount of Compression.
43	1″.000	0″.617	0″.383
44	1″.000	0″.617	0″.383
45	1″.000	0″.617	0″.383
		Mean.....	0″.383

Note.—In this particular explosive, the picric acid was fused before being added to the HNO_3.

XVI. *Tonite.*

Mode of preparation :

Gun-cotton (finely divided)..... 52.5 parts.
Barium Nitrate..... 47.5 parts.

Number of Experiment.	Length of Cylinder before Compression.	Length of Cylinder after Compression.	Amount of Compression.
46	1″.000	0″.624	0.″376
47	1″.000	0″.624	0.″376
48	1″.000	0″.624	0.″376
		Mean.....	0″.376

XVII. *Bellite.*

Mode of preparation :

$NH_4(NO_3)$..... 5 parts.
Metadinitrobenzene..... 1 part.

The ammonium nitrate was melted in a paraffin bath, and the $C_6H_4(NO_2)_2$, finely pulverized, gradually added and mixed with a wooden spatula until the entire mass became pasty. It was then allowed to cool and was granulated.

Number of Experiment.	Length of Cylinder before Compression.	Length of Cylinder after Compression.	Amount of Compression.
52	1″.000	0″.638	0″.362
53	1″.000	0″.640	0″.360
54	1″.000	0″.636	0″.364
		Mean.....	0″.362

XVIII. *Oxonite.*

Mode of preparation :

Same as in XV., Experiments 43, 44 and 45, except that the picric acid was not fused before being added to the nitric acid.

Number of Experiment.	Length of Cylinder before Compression.	Length of Cylinder after Compression.	Amount of Compression.
49	1″.000	0″.646	0″.354
50	1″.000	0″.646	0″.354
51	1″.000	0″.646	0″.354
		Mean	0″.354

XIX. *Rack-a-Rock.*

Mode of preparation :

$KClO_3$ ..... 79 parts.
Mononitrobenzene ..... 21 parts.

The chlorate was pulverized and saturated with nitro-benzene just before being used.

Number of Experiment.	Length of Cylinder before Compression.	Length of Cylinder after Compression.	Amount of Compression.
55	1″.000	0″.660	0″.340
56	1″.000	0″.660	0″.340
57	1″.000	0″.660	0″.340
		Mean	0″.340

XX. *Atlas Powder.*

Mode of preparation :

Sodium Nitrate ..... 34 parts.
Sawdust (fine) ..... 14 parts.
Magnesium Carbonate ..... 2 parts.
Nitroglycerine ..... 50 parts.

This explosive goes by the trade name of Atlas B.

Number of Experiment.	Length of Cylinder before Compression.	Length of Cylinder after Compression.	Amount of Compression.
58	1″.000	0″.665	0″.335
59	1″.000	0″.667	0″.333
60	1″.000	0″.669	0″.331
		Mean	0″.333

XXI. *Ammonia Dynamite.*

Mode of preparation :

Ammonium Nitrate..... 75 parts.
Paraffin..... 4 parts.
Charcoal..... 3 parts.
Nitroglycerine..... 18 parts.

Number of Experiment.	Length of Cylinder before Compression.	Length of Cylinder after Compression.	Amount of Compression.
61	1″.000	0″.696	0″.304
62	1″.000	0″.696	0″.304
63	1″.000	0″.612	0″.388
		Mean.....	0″.332

XXII. *Volney's Powder, No. 1.*

Mode of preparation :

Nitrated naphthalene No. 1 was first prepared as follows :
Nitro-sulphuric Acid, consisting of

H_2SO_4 (Sp. Gr. 1.84)..... 2 parts,
HNO_3 (Sp. Gr. 1.50)..... 1 part,

was made and allowed to cool. Of this

Acid mixture..... 4 parts,
Naphthalene..... 1 part,

were introduced into a vessel and the reaction allowed to proceed for about one hour. The yellow crystalline mass was then thoroughly washed, dried and pulverized.

Volney Powder, No. 1, as made, consisted of

Nitrated Naphthalene, No. 1..... 2.18 parts.
KNO_3..... 0.19 parts.
Sulphur..... 0.16 parts.

Number of Experiment.	Length of Cylinder before Compression.	Length of Cylinder after Compression.	Amount of Compression.
64	1″.000	0″.678	0″.322
65	1″.000	0″.675	0″.325
66	1″.000	0″.681	0″.319
		Mean.....	0″.322

XXIII. *Volney's Powder, No. 2.*

Mode of preparation:

Nitrated naphthalene No. 2 was prepared by treating naphthalene with nitric acid as follows:

Naphthalene.....1 part.
HNO_3 (Sp. Gr. 1.40).....4 parts.

The reaction was allowed to proceed slowly for four or five days, and the brown crystalline mass was then thoroughly washed, dried and pulverized.

Volney's Powder No. 2, as made, consisted of

Nitrated naphthalene No. 2.....1 part.
KNO_3.....3.30 parts.
Sulphur.....0.51 parts.

Number of Experiment.	Length of Cylinder before Compression.	Length of Cylinder after Compression.	Amount of Compression.
67	1″.000	0″.707	0″.293
68	1″.000	0″.707	0″.293
69	1″.000	0″.706	0″.294
		Mean	0″.294

XXIV. *Melinite.*

Mode of preparation:

Picric Acid (fused).....70 parts.
Gun-cotton (soluble).....30 parts.

The gun-cotton was dissolved in a mixture of

Ether.....2 parts.
Alcohol.....1 part.

The acid was fused and pulverized, and then thoroughly incorporated in the gun-cotton solution. The ether-alcohol mixture was afterwards evaporated.

Number of Experiment.	Length of Cylinder before Compression.	Length of Cylinder after Compression.	Amount of Compression.
70	1″.000	0″.718	0″.282
71	1″.000	0″.720	0″.280
72	1″.000	0″.722	0″.278
		Mean	0″.280

XXV. *Silver Fulminate.*

Mode of preparation:

Silver (gran.)..... 1 part,

was dissolved in

HNO_3 (Sp. Gr. 1.308).....20 parts,

and the solution thus obtained was poured into a flask containing

Alcohol (87%).....27 parts.

Reaction was promoted by bringing this last solution to a temperature of 212° F. As soon as the solution became turbid, it was allowed to cool, and

Alcohol (87%).....27 parts,

was again introduced into the flask, and the reaction again started. As soon as all reaction ceased, the opaque, white crystals were thoroughly washed and preserved in a black jar.

Number of Experiment.	Length of Cylinder before Compression.	Length of Cylinder after Compression.	Amount of Compression.
73	1″.000	0″.723	0″.277
74	1″.000	0″.723	0″.277
75	1″.000	0″.723	0″.277
		Mean	0″.277

XXVI. *Mercury Fulminate.*

Mode of preparation:

Same in general as in XXV., except as to proportions as follows:

Mercury..... 10 parts.

HNO_3 (Sp. Gr. 1.40).....120 parts.

Alcohol (95%).....110 parts.

Number of Experiment.	Length of Cylinder before Compression.	Length of Cylinder after Compression.	Amount of Compression.
76	1″.000	0″.725	0″.275
77	1″.000	0″.725	0″.275
78	1″.000	0″.725	0″.275
		Mean	0″.275

XXVII. *Mortar Powder.*

Dupont's Manufacture.

Number of Experiment.	Length of Cylinder before Compression.	Length of Cylinder after Compression.	Amount of Compression.
79	1″.000	0″.845	0″.155
80	1″.000	0″.845	0″.155
81	1″.000	0″.845	0″.155
		Mean	0″.155

Assuming then the nitroglycerine made on November 19, 1889, as the standard, and assigning to it, for the purpose of comparison, the value of 100, the results of the foregoing experiments may be conveniently recapitulated in the following table:

Name of Explosive.	Compression of Cylinder.	Order of Strength.
I Explosive Gelatine (Made from nitroglycerine after the Vonges Process.)	0″.585	106.17
II Hellhoffite	0″.585	106.17
III Nitroglycerine (Made Nov. 19, 1889, tested Jan. 6, 1890.)	0″.551	100.00
IV Nobel's Smokeless Powder	0″.509	92.38
V Nitroglycerine (Made Jan. 29, 1890, and tested on the same day. U. S. N. Torpedo Station Process.)	0″.509	92.37
VI Explosive Gelatine (Made from the last nitroglycerine.)	0″.490	88.93
VII Gun-cotton (U. S. N. Torpedo Station, Lot 100, 1889.)	0″.458	83.12
VIII Gun-cotton (Stowmarket 1885.)	0″.458	83.12
IX Nitroglycerine (Made according to the French process and tested on the same day.)	0″.451	81.85
X Gun-cotton (Made in Artillery School laboratory.)	0″.448	81.31
XI Dynamite No. 1	0″.448	81.31
XII Dynamite de Trauzl	0″.437	79.31

Name of Explosive.	Compression of Cylinder.	Order of Strength.
XIII		
Emmensite	0″.429	77.86
XIV		
Amide Powder	0″.385	69.87
XV		
Oxonite (Picric acid fused before being added.)	0″.383	69.51
XVI		
Tonite	0″.376	68.24
XVII		
Bellite	0″.362	65.70
XVIII		
Oxonite (Picric acid not fused.)	0″.354	64.24
XIX		
Rack-a-Rock	0″.340	61.71
XX		
Atlas Powder	0″.333	60.43
XXI		
Ammonia Dynamite	0″.332	60.25
XXII		
Volney's Powder No. 1	0″.322	58.44
XXIII		
Volney's Powder No. 2	0″.294	53.18
XXIV		
Melinite	0″.280	50.82
XXV		
Silver Fulminate	0″.277	50.27
XXVI		
Mercury Fulminate	0″.275	49.91
XXVII		
Mortar Powder (Dupont.)	0″.155	28.13

While the foregoing table gives correctly the *order of strength* of the various explosives contained in it, it cannot be said to give their actual *relative strengths*, since it was, for reasons given, impossible to arrive at their absolute strengths expressed in any unit of force. The true relations existing between them would be expressed by the relative amounts of work required to compress

the cylinders to the lengths shown in the second column, and, as already shown, the greater the amount of compression, so much greater the ratio for each additional 1-1000th of an inch of compression. From the results recorded in the above table, we may conclude that whatever other claims may be advanced for the various explosives tested, that with regard to their strength as compared with nitroglycerine is misleading. Under certain conditions, readily understood, some of these new inventions are capable of accomplishing more work than pure nitroglycerine, and as the performance of mechanical work may also be considered a measure of strength, it would at first sight appear that such claims are in so far sustained. But in by far the majority of such cases the additional strength is derived from the physical condition of the explosive rather than from any inherent property of the active principle. Let us look into this briefly.

Prof. C. E. Munroe, chemist to the U. S. Naval Torpedo Corps, in a hasty review of a "Report upon Experiments and Investigations to develop a System of Submarine Mines for defending the Harbors of the United States," submitted to the War Department by General Henry L. Abbot, Eng. Corps, U. S. A., says:

"In comparing the results obtained for pure nitroglycerine with those for Dynamite No. 1, there was revealed what at first sight appears to be a paradox.

"One pound of pure nitroglycerine was found to exert only 81 per cent. of the intensity of action of three-fourths of a pound absorbed by an inert substance which could add nothing to the heat or gases developed.

"This fact, which was discovered early in the trials, was considered so extraordinary as to require careful verification and study.

"The first explanation suggested was that it was due to a possible variation in the strength of the nitroglycerine itself depending upon a difference in the chemical composition of different samples.

"This was tested practically with different nitroglycerines, and with nitroglycerine and dynamite made from it, and it was shown, beyond question, that variations in the quality of the nitroglycerine

had nothing to do with it, and that the explanation must be sought in the physical conditions of the problems.

"General Abbot, therefore, suggests that in granulating nitroglycerine, by absorbing it in kieselguhr, the particles of silica slightly retard chemical action—since, in detonations, the reactions occur within the molecules—and as the resistance opposed by water is of a slightly yielding character, more time may be required to reach this condition than is afforded by nitroglycerine, pure and simple.

"This view is confirmed by the action of certain dynamites which are made so as to explode with exceeding rapidity, and which fall very low in the scale."

(Notes on the Literature of Explosives, by Prof. C. E. Munroe, B. S., May, 1883.)

This explanation is given as applying to the most extreme case in which nitroglycerine is the active principle in both explosives, the inert absorbent in the case of dynamite in no way contributing to its strength. Subjecting the explosives contained in the above table to a further test of strength by a comparison of the actual performance of mechanical work by proportional charges of each taken from the third column of the same table, the results of the previous experiments were fully verified.

THE VOLUMETRIC COMPOSITION OF WATER.

By Prof. E. W. Morley.

(*Abstract.*)

Gay-Lussac and Humboldt made ten experiments on the volumetric composition of water, with a mean error of $\frac{1}{250}$. Scott made at least twenty-five experiments, but without reducing the mean error.

The author was engaged in the same determination before Scott's papers appeared. After much labor he was able to procure hydrogen in which no impurity was present except nitrogen; he constructed an apparatus by which it was possible to detect and measure this residual impurity with a mean error less than $\frac{1}{100000}$; and finally he obtained hydrogen in which no nitrogen could be detected. Oxygen, by use of a similar apparatus, could be examined as rigorously; and finally was obtained with no impurity amounting to $\frac{1}{100000}$.

With gases containing no impurity, or containing only a known amount of a known impurity, twenty experiments have been made on the volumetric composition of water, besides four experiments which were lost, two by oxidation of mercury in the eudiometer, and two by accident to the apparatus during an experiment. Of these twenty results, the maximum was 2.00047; the minimum, 2.00005; and the mean, 2.00023. The mean pressure at which the measurements were made was 71 c.m. If, then, oxygen and hydrogen be measured at about the atmospheric pressure, the ratio in which they combine differs from an integral ratio by about one nine-thousandth part. The mean error of a determination was $\frac{1}{26000}$.

CARBON AN IMPURITY IN HYDROGEN AFFECTING DETERMINATION OF ATOMIC WEIGHT.

By Prof. E. W. Morley.

(*Abstract.*)

It is very difficult to obtain hydrogen free from carbon, if zinc is employed.

1. If zinc be dissolved in dilute acids, carbon contaminates the escaping hydrogen. No sample of zinc yet obtained by the writer gave hydrogen in which carbon was not quickly shown by passing it over heated copper oxide and into lime water.

2. If zinc be amalgamated, put into dilute acid and hydrogen obtained electrolytically, it still contains carbon, which has been proved in the same way.

3. If the purest zinc obtainable in commerce is heated in a vacuum, it gives off a gas containing carbon not in the form of the dioxide. Dr. William H. Burton kindly made many experiments on this matter: sixty grammes of zinc gave sometimes 0.8 c.c. carbon dioxide by combustion of carbon existing in the gas given off on fusion in some form other than carbon dioxide. All samples also gave off nitrogen.

4. It is obvious that metallic aluminium is likely to contain gases imprisoned in it and derived from metallurgical processes.

5. The electrolysis of an alkaline hydroxide is likely to give an impure hydrogen unless alkaline carbonates be removed. Such electrolysis, where a carbonate had been purposely added, in a voltameter most thoroughly cleaned from all organic matter, gave hydrogen containing a notable amount of carbon.

The bearing of these facts on the determination of the atomic weight of hydrogen is obvious.

A NEW FORM OF AIR THERMOMETER FOR TECHNICAL PURPOSES.

A comparison of several ordinary thermometers in use in a varnish factory showed, as was anticipated, considerable differences in reading under similar circumstances, these differences amounting to as much as 50° F. at a temperature of 500° F. or thereabout. A part of these differences could be ascribed to age, one of the instruments being about fifteen years old; but only a small part of the differences were due to any such cause. Inquiry of parties who make a business of correcting thermometers disclosed the fact that very little had been done in the way of correcting thermometers for high temperatures, and the conclusions finally reached were as follows:

It appears to be customary to assume the expansion of mercury to be uniform; but this is said not to be the case when we approach its boiling point, and I have not found any statement as to its expansion at high temperatures under pressure, as in the nitrogen filled instruments.

It is customary to assume the expansion of glass to be uniform; but this is not true when we approach the softening point, and in any given instrument it is impossible to tell how much of an error is thus occasioned.

In graduating a thermometer it is customary to assume that all that part of the instrument which at the time is full of mercury is immersed in the fluid which is under examination; and the error from this cause is stated by an expert to be probably as much as 80° F. at temperatures approaching the boiling point of mercury.

The improved method for graduating instruments for use at high temperature appears to be by the use of substances of high

boiling point, such as naphthaline and benzophenone. But different observers find different boiling points, even for a simple substance like mercury, and to get even approximate accuracy the experimenter would be obliged to determine with an air thermometer the boiling point of each substance he used, under the conditions of use.

Finally, the conclusion appears to be inevitable that the thermometer must be standardized under conditions essentially or absolutely similar to those under which it is to be used.

The conditions in the particular case in which I am interested are as follows: The thermometer tube is about three feet long, the graduation being confined to the upper one-third, and is inclosed in a tubular case, which terminates at the bottom in a steel cylinder which surrounds the bulb and is partly filled with mercury. This instrument is put in a copper kettle about two feet deep and has about a foot of the lower part of the instrument immersed in hot oil. Now any reading based on the ordinary graduation will under these circumstances be so erroneous as to be of no absolute value, and in fact, varnish makers do not go by degrees, but put arbitrary marks on their instruments and heat up to the mark, these marks not being at the same scale points of different thermometers.

I desired to make a thermometer which would give a reading within 5° F. of absolute accuracy, and the means I employ are as follows:

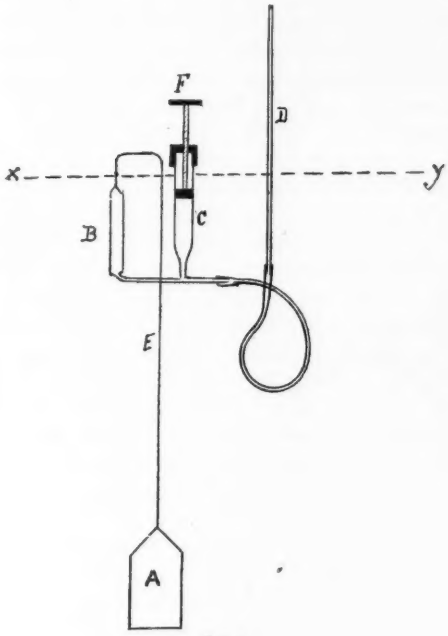

Fig. 1.

DESCRIPTION OF THE DIAGRAM.

A----Bulb.
B----Safety chamber for air and mercury.
C----Mercury cylinder.
D----Air pressure gauge.
E----Capillary tube.
F----Piston with screw to force mercury from C.
x y--Horizontal line showing level of mercury in capillary tube and gauge glass.

To avoid the irregular expansion of glass heated to near its softening point I use a bulb of metal, iron being selected; all the experiments which have been made tend to show that the rate of

expansion of iron at temperatures not exceeding 800° F. is very uniform, and on general principles we should expect this to be the case, since such temperatures are far from its softening point. A bulb of cast iron containing about 160 c.c. is fitted by an asbestos-packed joint to a capillary glass tube; the capacity of the bulb is of no consequence except that it should be large enough to make the capacity of the capillary tube insignificant. This glass tube is of any convenient length, say 3½ feet, and after bending downward is connected with a chamber to prevent the escape of air, as shown in the accompanying diagram. This safety chamber is normally filled with mercury, which is forced into it by a piston which is screwed into a cylinder filled with mercury which communicates with this safety chamber, and by this means the thermometer is made a constant volume one. This mercury also connects with a suitable pressure gauge; the form which I use is a closed tube containing air which is connected by a rubber tube with the safety chamber. Owing to the flexibility of the connection the gauge tube can always be placed so that the mercury in it shall be at the level of the mercury in the capillary tube and thus any correction on that account is avoided, and the whole apparatus being closed no correction for barometric pressure is needed. Of course an open mercury gauge tube could be used just as well if desired. What occurs when the bulb is heated is this: The expansion of the air is exactly counterbalanced by the operator who screws down the piston of the mercury cylinder so as to keep the mercury at the same point in the capillary tube; the only effect then of the heat is to increase the pressure on the mercury. The mercury transmits the pressure to the air in the gauge glass, which is compressed, and from the amount of this compression the temperature is calculated.

The calculation was made in the following manner: The expansion of air is $\frac{1}{273}$ of its 0° C. volume for each degree C. it is heated; or $\frac{1}{491.4}$ its 32° F. volume for each degree F. it is heated. $\frac{1}{491.4} = .002035$, and 1 volume air at 32° F. becomes 1.07733 vol. at 70° F. Since 70° F. is the lowest ordinary temperature in the places

where I am likely to use this instrument, for reasons which are obvious, I have selected 70° F. as my normal temperature. Other observers of course would calculate other tables. Now if we assume 70° F. as normal, what will be the expansion of a given volume of air? The given volume will fill the space which would be occupied by 1.07733 volumes if the temperature were 32° and therefore consists of $\frac{100000}{107733}=.9282$ of the amount of 32° air which it would take to fill the space; and as its expansion is calculated on 32° air, it will expand .9282 of .002035 = .00188 . . . . of its own 70° F. volume for each degree F. it is raised in temperature.

If air at 70° tends to expand .00188 . . . of its volume when heated 1° and is prevented from doing so by being enclosed in a rigid vessel, the pressure is equivalent to that produced by pumping in .001888 of the original volume and keeping the temperature at 70°. In that case we should have 1.001888 vol. condensed to 1.0000 vol.; and the original 1 volume would be condensed to .998113 as found by the proportion 1.001888 : 1 : : 1 : .998113; and so on. Thus a rise of 10° F., that is, to 80° F., would produce a condensation found by this proportion : 1.01888 : 1 : : 1 : .9814 and the space occupied by the condensing agent, which is the mercury in the gauge glass, is .0186 of the normal volume of the gauge, for *this* interval of 10° F. To get the volume at each successive interval of 10° F., multiply .0188 . . . by one, two, three, and so on, and add the product to unity for the first member of the proportion, whence we get a table, which does not, however, allow for the expansion of the iron bulb, nor for a change of temperature in the air of the gauge glass.

The cubical expansion of cast iron is .0000336 for 1° C. If the shell be heated to 800° F., from 70° F., which is equal to 405.6° C., it will expand .0000336 × 405.6 = .01363 of the original volume of the bulb. At 800° F. the volume of the air in the gauge is .4203 of its normal volume; and .4203 × .01363 = .00573, this latter fraction being the part of the normal volume of the gauge which the air in it will expand on account of the increase of the size of the iron bulb at 800° F. This makes a difference in reading such

as would be caused by a difference of about 16.8° in temperature. Actually the volume of the air in the gauge is .4203+.00573= .42603 of its normal volume, when the bulb is heated to 800° F.

In this manner a corrected table may be derived from the table already calculated, and this corrected table will show the absolute temperature of the air in the bulb, when the air in the gauge glass is at 70° F.

At 200° F. the volume of the air in the gauge glass if at 70°, is .8047 of its normal volume. Now if the original volume were raised to 80° F. it would have the volume 1.01888, and if this volume were subjected to sufficient pressure to compress it to .8047 of its bulk it would occupy $.8047 \times 1.01888 = .8762$. This exceeds the 70° volume by .0715, since .8762—.8047=.0715; and the difference for 10° in the bulb at this temperature (200° F.) is .0119; and $\frac{.0715}{.0119} = 6.01$; hence an elevation of 10° in the gauge air temperature makes a difference of $10 \times 6.01 = 60.1°$ in the reading and this amount should be added to the observed temperature under such conditions; and this ratio of 6.01 : 1 is true not only of the temperature of ten degrees in excess of 70° in the gauge glass, but also of all temperatures in excess of 70° when the bulb temperature is 200° F. In this way a table of corrections may be calculated for the various bulb temperatures to be observed. The ratio increases as the temperature rises. The air gauge of the instrument should contain a small thermometer, and a sliding scale can be arranged if desired.

A RAPID AND EASY METHOD OF ESTIMATING UREA IN URINE.

By E. H. Bartley, M. D.

This apparatus was designed for the use of physicians rather than chemists. The process is a modification of the well known hypobromite process, by which the urea is decomposed, with the formation of CO_2, H_2O and free nitrogen. The first two of these remain in solution, while the nitrogen escapes and is measured.

The hypobromite solution is usually prepared by dissolving 25 c.c. of bromine and 100 grms. of sodium hydroxide in 250 c.c. of water. To avoid this tedious and disagreeable preparation I prepare the solution as needed by mixing, in the apparatus, a 20% solution of potassium bromide and sodium hypochlorite (Labaraque's solution), in the proportion of one of the former to about three of the latter.

The result of this mixture is a solution of sodium hypobromite and potassium chloride, answering in every way the requirements of the process.

The two solutions keep well, while the hypobromite solution does not.

The apparatus consists of two parts: First—A graduated pipette delivering 1 c.c. Second—A graduated tube about 1 cm. in diameter and 30 cm. long, closed at one end, and graduated from this closed end throughout its entire length. The graduation is made as follows: A standard solution of urea is prepared containing 10 grains to the fluid ounce. With an ordinary gas tube it was found that 1 c.c. of this solution gave 8.2 c.c. of nitrogen.

This is about the average urea strength of normal urine. Each 8.2 c.c. on the new tube are then divided into ten principal divisions, and each of these into four smaller divisions.

Each of the principal divisions then represents grains per fluid ounce, when 1 c.c. of the urine is taken.

By a similar method the graduation may be made to represent grams per litre.

The process is conducted as follows:

Holding the ureometer in the left hand pour in enough of the 20 per cent. solution of potassium bromide to fill it to the fifth division; then add hypochlorite solution to the eighteenth or twentieth mark. The tube is now inclined and water added to about the twenty-fifth division. With the small pipette 1 c.c. of urine is now added, allowing it to run down the side of the tube so that it shall mix with the water floating upon the heavier solution below. The open end of the ureometer is now firmly closed with the thumb, and its contents thoroughly mixed by inverting it a few times. When the effervescence ceases, which usually takes about two or three minutes, invert and read off the height of the liquid in the tube.

The thumb is now removed under water, the tube depressed to bring the liquid in the tube to a level with the water in the outer vessel, and a second reading taken. The difference between the two readings gives at once the number of grains of urea in each fluid ounce, or grammes per litre, according to the construction of the scale.

This number multiplied by the number of ounces passed in twenty-four hours, in the one case, or litres in the other, gives the amount of urea passed in twenty-four hours, which should be about 500 grains, or 30 to 33 grms. The instrument may be had of Eimer & Amend.

NOTE.—Experiments made to determine whether the apparatus could be used to determine total nitrogen, after decomposition in the Kjeldahl flask with sulphuric acid, gave good results.

Experiments with ammonium chloride showed that but one-third of the nitrogen was set free from this salt, while the sulphate seems to yield all of its nitrogen.

STUDIES UPON RESINS.

By L. H. Friedburg, Ph. D.

Resins have, at different times, been subjected to chemical treatment and as far as some of them are concerned, we have quite valuable knowledge of the same. We know of abietinic acid in rosin, we know of a peculiar facility of reaction between some of them with phenol, but still, if asked, what is a resin, chemically speaking, cannot give an explanation.

I.—COPAL RESIN.

I have begun to study, qualitatively, a resin of great practical importance in the manufacture of varnishes, the so called copal. The difficulty which meets us at the outset of such researches is this: Are we always sure of finding the same raw material under such a name, for example, as copal? What is copal, not chemically but commercially?

We find soft copals, such as damar, which is soluble in ether, but there are other half hard, and still other perfectly hard copals which only partially dissolve in different solvents, but which can be made soluble by allowing them to suffer previously a chemical change. After this, however, we have no longer to do with the raw product "copal," but with a product of decomposition of the same. The soft copals are said to be found mainly on the islands of Sumatra, Java, Molucca and the Philippines, also in Australia. The hard copals are imported via Calcutta and Bombay from some places in Africa. All of these have very different appearance and different physical properties, so different that it seems almost impossible to attribute the same name to them. Their origin is not very clear. The hard copal is called hard animi in England; it is imported into Europe via Calcutta and brought there by African

traders from Zanzibar and the adjoining coasts. The hard copal from Bombay is brought to that place from Madagascar. It is found in Madagascar, Mauritius, Bourbon and is said to be furnished by a tree *Hymenæa Verrucosa.* (Jussieu calls it *Taurouyon*). On l'Ile de France the tree is called *copallier.* We learn also that *Hymenæa Courbaril* of Cayenne furnishes a substance similar to hard copal. (Henry Violette, Fabrication des Vernis, p. 302 to 304).

Now, the fact of a vegetable origin of copal seems to be evident. But the growers mix pell mell, soft and hard copals, with other resins and ship them as hard copal. The dealers assort these mixtures and the manufacturers of varnish must rely upon them as well as upon their own knowledge in buying a uniform article. So much as to the origin of copal. The chemical properties of hard copal, as far as the varnish manufacturers are interested in them, are the following: it is insoluble as a whole in alcohol, ether, and oil of turpentine, but becomes soluble in these latter two when previously heated.

Since most hard copal varnishes are solutions in oil of turpentine and linseed oil, we have to remember how the manufacturers proceed. They heat the copal until it melts and continue this heating according to routine. At the same time oil of turpentine is heated to boiling, and at a certain stage of this manipulation the two hot liquids are mixed together in certain proportions. If the copal is not hot enough, and if the hot oil of turpentine is not allowed to run slowly into the former, a clear solution is not obtained. That a great manufacture (dangerous also, as far as inflammability and irritating exhalations are concerned), rests thus upon a most empirical basis is surely the reason for the issue of innumerable patents in regard to changes in the same, changes which, however, have not generally been adopted. (See Ure's Dictionary, 7th Ed., p. 1055.)

But the chemist may approach this task in a different way. He arrives at the knowledge of the real composition of a compound or a mixture through the study of products of decomposition of the same. The synthesis of indigo was only effected after a most perfect study of its products of decomposition had been made.

We know from the above that copal suffers decomposition by heat in such a manner as to leave a residue soluble in boiling oil of turpentine to a varnish. Consequently the exact conditions of this decomposition should be ascertained. Heating copal slowly in a flask connected with a Liebig's condenser, a light flowing distillate which has an agreeable odor, suggestive of terpenes, even of lemon, passes over at first. This odor indicates the presence of the *limonen*, of *Wallach*. (*Ann. Chem., Liebig*, **252**, *108*.) Shortly after this, vapors arise which cannot be condensed and which are of an irritating nature, the mass turns darker brown, and the boiling continues in this way until almost all of the copal is destroyed. Performing this experiment with the aid of a thermometer in a fraction flask, we see the aromatic oil distil at temperatures above 100° C. up to 170° C. or 185° C. * The mass boils quietly, then the white vapors, which partially condense to a liquid of empyreumatic odor, begin to appear when the temperature of 215° C. is reached, the mass turns very dark, boils quietly without sending off visible vapors and the thermometer *falls* suddenly and rapidly to 170° C., or even below that temperature. It seems to follow from this, that while up to 215° a fractional separation of a mixture is going on, when this temperature is reached the heat applied is partly used for more profound inner decomposition of the residue in the flask. If, therefore, the copal be only heated to 182° C. until no more distillate is obtained, and then allowed to cool, we avoid this latter decomposition.

Copal thus heated to 182° C., when allowed to cool, yields a very brilliant glass-hard, translucent resin, which is soluble with the greatest facility in cold or warm oil of turpentine.

The distillate obtained forms ⅓ of weight of the raw copal used.

In order to obtain the first volatile oil of agreeable odor in purer

* In all the data given in this paper in regard to temperatures, the thermometer is always supposed to be in the *vapor* above the liquid and never immersed *in* the liquid. In a subsequent paper experiments will be reported which I have made with a view to determine both temperatures simultaneously, those of the melted gum as well as of the vapors formed.

form, distillation in a current of steam was resorted to. The oil obtained floated on water, but was not obtained in quantities sufficiently large.

The experiment was repeated on a larger scale (with the liberal aid of Dr. Alsberg and in his factory) in a copper still and with 45 pounds of steam pressure.*

Then again the cooler was not adequate to allow full condensation, and the room was filled with an agreeable odor suggestive of lemon terpenes. The residue in the still, when cold, was very hard, but porous and consequently brittle. It did not dissolve in oil of turpentine.

Next it was ascertained what liquids would dissolve copal without previous treatment. It is said that the distillate obtained from copal by destructive distillation is a solvent for melted copal. But the evil odor makes this unmanageable. It was proved to be correct, as found by former investigators, that aniline and its homologues dissolved copal very readily.

Nitrobenzol or chloroform dissolved copal, the former better than the latter, which, like almost all commercial chloroform was not free from an inflammable admixture, perhaps undecomposed acetone.

Phenol dissolves copal well. This is a known and patented fact. I found cyneol to be an extremely good solvent for copal. (For Cyneol, see *Ann. Chem. Liebig*, **225**, 295.)

An astonishing reaction took place when copal was treated with benzaldehyde. This latter dissolves in a most perfect manner at first. Shortly afterwards the whole mass thickens to a light amber colored jelly, not unlike new peach gum, only much softer. It is almost impossible to handle this mass. After some experience it is possible to bring it into a flask and to subject it to distillation. Better results are obtained when ground copal is put into a flask and the C_6H_5COH added. A perfectly clear solution is obtained. At 80° C. the jelly form is reached, and care has to be taken that continued heating does not crack the flask.

*I also owe to Dr. Alsberg's kindness a liberal supply of a most uniform, rather pale copal (Kauri gum), of a quality superior to that ordinarily used for varnishes.

Then thick yellowish white fumes are driven through the cooler and C_6H_5COH and some H_2O distil off. Later an oil which irritates the eyes follows. Finally an oil distils which condenses to thick white crystals either in the condensing tube or according to temperatures in the receiver. This crystalline mass is soluble in ether and also in benzaldehyde. When this experiment was performed after prolonged treatment of copal with benzaldehyde, under an upright condenser, the result was similar. On distilling, the temperature must not rise above 215° C. or more profound decomposition takes place.

A peculiar fact connected with this experiment was that an increase in weight of 8% was noticed, when the quantity of products obtained was compared with the quantity used. This is suggestive of oxidation through atmospheric oxygen, as far as the distillate is concerned. These experiments will be followed up closely and reported upon later.

Resuming the study of solvents for crude copal, oil of turpentine was inverted at + 270° and seemed to be a solvent. Glacial acetic acid dissolved copal partially. Carbon disulphide is taken up by copal in large quantities, copal beinga colloid with the former. On adding more disulphide the plastic mass rises to the surface and on filtering and drying becomes brittle. The solution of CS_2 was evaporated on a water bath and furnished a gummy, light yellow colored mass of aromatic odor. The plastic mass when exposed to air resumes a hard and brittle form. Copal heated together with glycerine without pressure does not form a fatty substance. The experiment in pressure tubes has not yet been performed.

When conc. H_2SO_4 acts upon copal, sulphur dioxide is generated and the mass turns dark brown.

Chromic acid, even boiling, does *not* act upon copal.

When the oxidizing mixture of potassium dichromate and H_2SO_4 is used a strong action takes place and an odor suggestive of that of the dried leaves of *Asperula Odorata* is noticed.

Strong sodium hydrate of 40° Be. does not act appreciably.

Potassium permanganate attacks copal on boiling.

When boiled with nitrosylsulphuric acid, a reaction, which is

not violent takes place. It appears that a nitro product is formed. The product of reaction when poured into water separates yellow flocks which dissolve in alkalies with mahogany color.

Sulphur introduced into boiling copal develops hydrogen sulphide. The mass turns very hard and black, and becomes unmanageable. For instance, it is not easily attacked by alkaline solutions.

A very strong reaction takes place when reducing substances are brought together with copal. Alcoholic ammonia acts strongly when warm. The alcoholic solution deposits besides sulphur, a *white* solid compound when neutralized by acids. The residue that did not dissolve in alcohol when boiled with water puffs up to a very porous mass, not unlike beaten white of egg. This mass when dried is easily crushed to a fine powder which is entirely volatile when gently heated.

Watery ammonium sulphide, reacts on boiling, upon copal. The warm solution is blood red but on cooling becomes lighter colored. The residue after boiling with water and treating with dilute H_2SO_4, develops lemon odor.

Watery ammonium hydrate was used in order to see whether an abietinic acid salt might be obtained. The product of the reaction turns at once snow white; it does not float upon the liquid but sinks in it as a heavy white powder. Also this ammonium salt volatilizes entirely, without leaving a residue.

Solid potassium cyanide fused with copal developed very bad odors and was abandoned.

The reaction of grape sugar in alkaline solution is an exceedingly lively and sudden one, which could not be tempered.

Also alcoholic potassium reacts with copal when moderate heat is applied.

Strong hydrochloric acid attacks copal slightly.

Zinc dust heated with copal develops currents of hydrocarbons, some of which do not condense, while iron powder is without action. Zn and HCl do not show any reaction.

The experiments performed so far are those of destructive distillation, of oxidation and reduction as stated above. Furthermore, the remarkable reaction with aldehydes, such as benzalde-

hyde and that with nitrosylsulphuric acid to form nitro products and the formation of an ammonium salt which is as volatile as ammonium chloride.

All these experiments will next be performed quantitatively, and should then allow definite conclusions in regard to my assumption that the crude copal consists of three typical components, a terpene, an easily oxidizable hydrocarbon not a terpene, and an acid which may be homologous with abietinic acid. This acid has the peculiarity of being an amorphous, glass-hard and translucent mass.

NEWPORT, R. I., Aug. 6th, 1890.

ON THE RELATIVE INTENSITY OF CHEMICAL FORCE.

By L. H. Friedburg, Ph. D.

We are accustomed in chemistry to use the words "chemical attraction," or "affinity," without forming a distinct conception as to the manner in which this affinity may act.

The different degrees of readiness with which elements combine suggests the question: What is the cause of this difference in behavior? Some chemical compounds are less stable than others. Even the elements in their pure molecular state are split with greater facility in some cases than others into atoms before entering into new compounds. We are accustomed in this latter case to speak of a resistance which the molecule of an element offers before it enters into combination with other elements. We note that there is a force acting between the atoms of the same element and between those of different elements. We call this the chemical force.

Amongst the newer stereochemical conceptions there is one, expressed by Alex. Naumann* in the following words:

"The greatest possible effect of the attractive force between carbon atoms takes place when the directions of attraction coincide with the line which unites the centres of gravity of two such atoms. If the directions of attraction deviate from this line, only that component of the total attraction links the atoms, which lies in the direction of this line." If this be true, it follows naturally that even two carbon atoms may be held in combination by a greater chemical force than that which holds two other carbon atoms together. The reason is to be found in a different stereochemical arrangement.

* Ber. d. Chem. Ges., **23**, 477, 1890.

In applying this idea to the chemical force in general, we find that this force is dependent upon the direction in which it is exerted. Older speculations, notably those of Berthollet, have impressed upon us the idea that the atomic weights have an influence upon this force, although not in such a general sense as Berthollet assumed it. We must add to this the principle of valency, which tell us that the atoms of some elements offer one point of attack to the chemical force while others offer two, three or four points of attack.

Thus we consider chemical force to be dependent upon atomic weight, valency and the direction in which this force acts between the atoms. From this standpoint we may explain chemical action with greater clearness than the mere use of the words affinity or chemical attraction admit of. For example, we find in the first place, that some elements are more ready to display chemical force than others. A hydrogen molecule is more easily split into atoms than a nitrogen molecule. We notice here that for a molecule of an element there is no difference of weight to be noticed, since these molecules are supposed to consist of two or more atoms of the same weight. But the difference of valency and of the direction of the action of force between such molecules need not be the exclusive cause of such difference in behavior as is displayed by hydrogen and nitrogen. The univalent hydrogen atom is bound by a chemical force acting in a straight line to another atom of hydrogen exactly equal to the first; this line evidently has the direction of the line which unites the centres of gravity of the two atoms. We purposely neglect here the theory of rotation of such a system. Two triatomic nitrogen atoms, forming a molecule, are supposed to represent the figure of a three sided double pyramid, the nitrogen atoms occupying two opposite corners.* The direction of any of these valencies which are supposed to act along the edges of the pyramids, certainly do not coincide with the line uniting the centres of gravity of the two atoms. We surmise, therefore, that although one single valency of the triatomic nitrogen atom is equivalent to one hydrogen valency, that the strength of chemical action within the nitrogen molecule cannot be exactly three times

* Ber. d. Chem. Ges., **23**, 11, 1890.

as large as within the hydrogen molecule, but that it must be smaller to some extent.

It has been suggested above that the atomic weight might, in some way, come into consideration even when molecules of the elements were conceived of. If the chemical force is supposed to be the result of the vibrating ether coming into contact with elementary atoms, it is clear that this force will more easily join together the lighter atoms than the heavier, that consequently the heavier atoms are kept together by an absolutely stronger pressure. If we add that this force finds three points of attack in the nitrogen atom, and but one in the hydrogen atom, we see the possibility of the nitrogen molecule being less ready to display chemical force towards molecules of other elements than the hydrogen molecule.

We may extend this example to the *different* mono-, di-, tri- and tetratomic elements. We shall find, however, that oxygen and sulphur, for example, although both diatomic in *certain* compounds, show a difference in regard to readiness of combining with other elements. The influence of the atomic weight being perceptible in the above sense. Of course, we must allow for the different states of aggregation. Solid sulphur will be slower to react than gaseous oxygen; but we may consider both at the same temperatures in gaseous form, and thus eliminate this influence. As an example, we shall find that carbon dioxide is easier to prepare synthetically than carbon disulphide, water than hydrogen sulphide.

Concerning the *stability* of a chemical compound *formed* from atoms of different elements we find several cases possible.

Firstly, such compounds are more or less stable at ordinary conditions, and without being acted upon by other chemical elements or compounds. This is illustrated by ammonia gas and nitrogen chloride.

The hydrogen atom being fourteen times lighter than the nitrogen atom, it will not be able to bend the valency of nitrogen from its original direction, and the three hydrogen atoms may be considered as symmetrically arranged with reference to the nitrogen. The chlorine atom being two and a half times heavier than

nitrogen, the three chlorine atoms representing a weight seven and a half times that of the nitrogen atom, may influence the directions of valency of this latter.

A compound is thus formed (assuming for brevity's sake that its formula be NCl_3) which gives us the conception that chlorine atoms in this case are more nearly in reach of and more likely to act upon one another to form chlorine molecules, and that nitrogen has a tendency in its valencies to spread out to their original direction, forming a nitrogen molecule with a similarly moving nitrogen atom. The whole compound is thus in a state of unstable equilibrium which is easily disturbed with the well known results. In *this particular case* it is difficult to decide whether the atomic weight of chlorine contributes more to the production of an explosion than the tendency of the curbed nitrogen valencies to spread back and to form an original nitrogen molecule. For the other explosive nitrogen compounds the case is a little more complicated, but it follows by analogy that the cause of the decomposition should not be ascribed to the above mentioned peculiarity of nitrogen alone. In all the explosives which contain *nitro* groups (potassium nitrate of gunpowder *not* excluded), it is just as much the tendency of oxygen towards new combinations which causes the explosion when oxidable elements are contained in the *same* compound, as the above peculiarity of nitrogen. Why does not nitric acid, when put upon copper, explode to form nitrogen, copper oxide and copper nitrate? The reason that nitro-products are so largely used for explosives is that they are practically manageable, that they are in other words, not the most explosive bodies. If it were possible to replace in nitroglycerine the three nitro groups by three ClO_2 groups, we should have a more explosive compound. A mixture of potassium chlorate and permanganate can only be pulverized together with the utmost care, as the dry salts may blow up during this treatment. There is no nitrogenized explosive substance known which does not contain oxygen as well as nitrogen.

There are many chemical compounds containing nitrogen in a semi-molecular state, the so called diazo compounds which contain the chromogene group N_2, some of which are beautiful and toler-

ably fast dyes and not explosive, while it is easily understood that if such diazo compounds do decompose under the influence of chemical reaction, the nitrogen is set free as such in the molecular state, simply because this molecule of nitrogen exists two-thirds preformed in the substance. Also here we see a marked difference between nitrogen and oxygen. Oxygen in a semi-molecular state, so to speak, often shows a tendency to reform its molecule under explosion. Peroxide of hydrogen and the chlorine or iodine compounds of oxygen illustrate this fact.

It must not be forgotten that the oxygen molecule and the sulphur molecule, its analogue in this sense, may be considered as containing dipolar atoms which allow of free rotation around an axis formed by one of their valencies. *This* rotation does not exist in the trivalent nitrogen. The explanation does not seem to be remote, if we admit that this rotation, when suddenly *stopped* by the beginning of combination of oxygen with other elements, causes the production of heat and light. As long as this rotation is partly existing, however, as in the peroxides, the tendency to return to the molecular state is noticeable, considering that oxidation takes place at the same time if the opportunity is offered.

We may note here the fact that phosphorus, antimony and arsenic, represent elementary conditions of molecules similar to that of nitrogen. A difference in the behavior of chlorine compounds of these, when compared with nitrogen chloride, strongly supports our surmise that the atomic weight is one factor which influences the intensity of chemical attraction between atoms. The greater atomic weights of arsenic, phosphorous or antimony as compared with nitrogen prevent the influence of the heavy chlorine atom upon the curbing of the directions of their valencies as we supposed this to take place in nitrogen chloride.

It does not help our purpose here to consider the peculiarity of tri- and pent- atomicity of these elements. It is sufficient to say, that under certain conditions a body may be prevented from offering all its points of attack to a certain force. If we take a horseshoe magnet and only allow one of its poles to attract a piece of iron while the other remains free, we should not be allowed to speak of a unipolar magnet. We may consequently

settle this question here by assuming the higher number of valencies to be always shown when compounds exist at lower temperatures. If we surround phosphorus pentachloride with a heated mantle we attain a dissociation into chlorine and trichloride, similar to heated ammonium chloride which furnishes HCl and NH_3 gas.

In many of the cases so far mentioned we recognized reactions, which in a former chemical period were spoken and thought of as taking place between the atoms as between animate beings, by predisposition rather to combine with this than with that element. The mere word affinity, changeable as the sense was in which it was applied at different periods, indicates this animation. The tendency of modern chemistry is to attempt to reduce these reactions to general principles of physics starting from chemical phenomena and remaining upon the chemical standpoint.

We must finally consider another case, which illustrates our endeavor. It is the one examplified by chlorine, when acting upon bromides or iodides, when either bromine or iodine are liberated. We find here cases suggesting reversed conditions as we considered them in chloride of nitrogen and ammonia when compared. The chlorine atomically lighter than bromine is not able to influence the rotation of its unipolar ally hydrogen (as in hydrochloric acid) or of alkali metal in salts *as much* as the heavier bromine or the still heavier iodine. The compounds of iodine with metals show a remarkable tendency towards decomposition with formation of an iodine molecule, although the iodine compounds are still stable when compared to nitrogen chloride.

The *relative* intensity of the chemical force that acts between atoms to form molecules of elements or of chemical compounds must not be lost sight of in all our chemical views.

We have shown the strong points in favor of a more physical consideration of chemical phenomena from a chemical standpoint and it seems as if most chemical reactions might be satisfactorily explained in this way, even to-day.

NEWPORT, R. I., Aug. 7th, 1890.

NOTE UPON BÜTSCHLI'S EXPERIMENTAL IMITATION OF PROTOPLASM.

By C. A. Siegfried, Surgeon U. S. Navy.

During the past few years Prof. Bütschli, of Heidelberg, has made many attempts, and now succeeds in producing under the microscope seemingly amœboid movements. He has communicated to Prof. Ray Lancaster, of England, a full account of his methods by which he attempts to imitate protoplasm. A medium sized watch glass or flat dish must be filled with a thin layer of common olive oil and be placed on a water bath or small cupboard at a temperature of about 50° C. The great point is to select the right moment at which the oil attains the proper degree of thickness and viscosity; this moment can, however, only be found by systematic trials. After three or four days a trial may be made. Should the drop not have become finely vesiculate and exhibit little or no streaming, the heating process must be continued and a trial made on the succeeding day. If the oil becomes too thick it will form frothy drops, and in such cases a small quantity of ordinary olive oil must be mixed with it.

The vesiculate drops are thus prepared: In a small agate mortar a small quantity of dry carbonate of potash is ground to a fine powder. This is breathed on till the salt beeomes slightly moist, and then a drop of oil must be added; the two constituents should be mixed until they form a thickish paste. A few drops of this paste, about the size of a pin's head or smaller, are placed on a cover glass, the corners of which are supported by pegs of soft paraffin. Then a drop of water is placed on a slide and the cover glass is put over it in such a manner that the drops of paste

Quarterly Journal Microscopical Science, xxxi, 1890, pp. 99 and 103.
Journal Royal Microscopical Society, 1889, p. 731, 1890, p. 403.

are immersed in the water, but are not much compressed. The preparation is then placed in a damp chamber, and remains there about twenty-four hours, when the drops have a milk white and opaque appearance. The preparation is then well washed out with water, which is supplied at one edge by a capillary tube and drawn out by blotting paper at another.

If the drops have turned out well they will begin almost at once to move about rapidly and change their shape continuously. The water under the cover glass must now be displaced by glycerine diluted with an equal bulk of water, when a vigorous streaming movement will be exhibited. The amœboid movements are generally more distinct if the drops are somewhat compressed. If the drops do not stream they can be generally made to do so by slightly tapping the cover glass, by applying gentle pressure, or sometimes by breaking up the drops. It is especially interesting to see how fast and beautifully the drops creep to and fro in the water or half diluted glycerine, even when they are not compressed. The streaming movement on the other hand is better seen if the drops are somewhat compressed ; this may be done by inserting under the cover glass a piece of broken cover glass of medium thickness, and then removing the paraffin pegs. This streaming movement is best demonstrated twenty-four hours after the addition of the glycerine, as the drops will then be thoroughly cleared and transparent. The movement and streaming are much more marked and distinct if the drops are examined on a stage warmed to 50° C. Prof. Bütschli advises repeated trials if the first experiments prove unsuccessful. Saponification, and vibratory movements inseparable from all inhabited spots, do not offer satisfactory solutions, and I take the liberty of asking the members of the Society for some little discussion regarding the probable causes concerned.

THE USE OF THE GOOCH CRUCIBLE AS A SILVER VOLTAMETER.

By Dr. Morris Loeb.

For the exact measurement of electric currents, no method is more convenient and more free from objections than the determination of the amount of silver deposited from a neutral solution of a silver salt. The sole source of error, especially where weak currents are concerned, arises from the imperfect adhesion of the silver upon the cathode. The latter is generally a platinum crucible, and the silver, except for densities of current not always attainable, is deposited in minute scales and needles, instead of forming a coherent coating. In the subsequent washing and decantations, these particles are readily detached and carried away, and a loss is occasioned which becomes very appreciable when the total deposit does not exceed a few centigrams. A Gooch crucible, with asbestos felting over the holes, would be a far better form of cathode, if it would only hold the solution during electrolysis without leaking. I have attained this very satisfactorily, by replacing the ordinary platinum cap with a glass siphon of the shape indicated in Fig. 1.

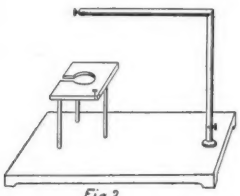

Fig. 2.

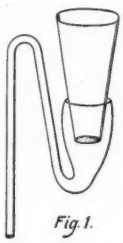

Fig. 1.

The crucible is made on a rather taller and narrower pattern than is usual, and it fits quite snugly into the upper portion of the cup

of the siphon. The two are united by a bit of rubber drawn over the junction; the rubber should be freed from sulphur, although there is no real danger of contact with the silver solution.

The apparatus is filled with the silver nitrate solution, so that the top of the siphon is not quite reached and is set upon the stand, Fig. 2. After the completion of the electrolysis, adding a little liquid causes the siphon to act and to drain off every drop of nitrate solution, without in any way disturbing the deposit; the lixiviation with hot water is equally expeditious, and the crucible can then be detached from the siphon, dried and weighed.

The stand for this voltameter is seen in fig. 2. The crucible is hung in a brass block, the conical hole in which fits exactly around its upper third; to this block the negative wire of the circuit is to be attached.

The positive wire is connected with long horizontal cone, which is isolated from the cast-iron base, and from which the silver cone that forms the anode is suspended within the crucible by a silver wire.

ON A NEW PROCESS FOR THE EXTRACTION OF INDIGOTIN FROM COMMERCIAL INDIGO.

By Thos. M. Morgan.

A few years ago I had occasion to use indigotin as pure as possible and in considerable quantities, for industrial purposes, and endeavored to obtain it from commercial indigo by some of the well known methods. Eventually I adopted the following process, which is easy of execution and gives a satisfactory yield.

Commercial indigo, finely ground and intimately mixed with about an equal weight of zinc dust is spread in layers, about an inch deep, on thin boards, and introduced into a steam chest so constructed that it can be closed air tight, and provided with a steam pipe for the introduction of steam and one for its exit; also with an aperture for the introduction of a solution of sulphurous acid. The indigo mixture is also screened, to prevent condensed steam dropping upon it. When these arrangements are complete the air is driven out by a rapid current of steam; then the steam valve is nearly closed, a little steam being allowed to pass through the apparatus, so as to prevent the entrance of air. Next the solution of sulphurous acid is introduced, a little at a time, so as to saturate the steam in the chest with sulphur dioxide, and it is maintained in this condition while the reduction of the indigo is going on.

The reaction between the zinc, sulphur dioxide and indigotin goes on rapidly, and in about one or two hours the indigotin should be completely reduced. It then presents a dirty yellow or greenish yellow color, and when it dries, which it quickly does on taking from the steam chest, is not liable to rapid oxidation, but may be kept for several days without much change. From the mixture the indigo white may be recovered in an extraction apparatus by means of wood spirit, or by digestion in flasks filled to the neck with the same solvent. On exposure of the solution in shallow vessels to the air the indigotin is precipitated pure and crystalline. The yield is large, and probably a theoretical one when all necessary precautions are employed.

FLUORIDES AS AGENTS FOR SOFTENING HARD WATERS.

CHARLES A. DOREMUS, M. D., PH. D.

A study of the various chemicals that might prove serviceable for softening water was begun as the result of my attention having been directed to the very serious difficulties that are met with in the practical use of lime, soda ash and caustic soda. Early in the work the fluorides, such as sodium fluoride, seemed to offer a fruitful field of investigation and subsequent events proved that not only sodium fluoride, but other fluorine compounds possess admirable qualities for these uses.

Laboratory experiments were first made with sodium fluoride alone and also in conjunction with other chemicals. These were followed by experiments on a large scale, the results of which were very satisfactory. The precipitation of magnesium is especially thorough and noteworthy. These experiments have since been extended and have passed also into a regular employment of the chemical.

The fluorides do not appear to have as yet had any extended commercial use, nor to have been applied heretofore for treating water. Failure to find any mention of such fact in chemical literature has been supplemented by a similar failure on the part of Patent Office officials here and abroad to discover any to cite in interference.

One of the chief difficulties met with in the pursuit of the work was my inability to obtain in open market any fluoride in quantity, or at any but an exorbitant price. This has been so far overcome that sodium fluoride has been manufactured for me in large quantities at a figure which to the consumer will not prove prohibitive.

COLLEGE OF THE CITY OF NEW YORK, August 7, 1890.

MINUTES OF SEPTEMBER MEETING.

*Regular Meeting, Sept. 19, 1890.

Vice-President Breneman in the chair.

The Corresponding Secretary, Dr. Hale, read the minutes of the Newport meeting which were accepted as read.

The following gentlemen were elected to membership:

Dr. Lewis H. Laudy, School of Mines, N. Y.

Chas. A. Pitkin, A.M.Ph.D., Coll. Phys. and Surg., Boston, Mass.

Major W. R. Livermore, U. S. A., Newport, R. I.

Mr. G. W. Patterson, Newport, R. I.

The following names were proposed for membership:

Stephen H. Emmens, Emmensite Explosive Co., Emmens, Pa.

F. E. Thompson, Headmaster Rogers High School, Newport, R. I.

Dr. Geo. Archbold, Chemist U. S. N., Washington, D. C.

Prof. G. C. Caldwell, Professor of Agricultural Chemistry, Cornell University, Ithaca, N. Y.

Chas. E. Colby, Ph.D., Professor of Organic Chemistry, School of Mines, N. Y.

Prof. W. H. Seaman, Professor of Analytical Chemistry, Missouri School of Mines, Rolla, Mo.

Dr. Chas. E. Pellew, School of Mines, N. Y.

Hugh Hamilton, M.D., Harrisburg, Pa.

Edward Gudeman, Honorary Assistant in Chemistry, School of Mines, N. Y.

Dr. Alfred Springer, Pres. Springer Torsion Balance Co., 46–50 E. 2d street, Cincinnati, O.

Dr. H. J. Wheeler, Chemist Agricultural Experiment Station, Kingston, R. I.

Dr. Edward S. Wood, Professor of Chemistry, Harvard Medical School, Cambridge, Mass.

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*Adjourned from Sept. 5, 1890.

Dr. S. A. Lattimore, Professor of Chemistry, University of Rochester, Rochester, N. C.

Prof. Chas. E. Brewer, Professor of Chemistry, Wake Forest University, Wake Forest, N. C.

Prof. R. W. Jones, Professor of Chemistry, University of Mississippi, Oxford, Miss.

Prof. Peter T. Austen, Professor of Chemistry, Rutgers College, New Brunswick, N. J.

Mr. Harry Snyder, Instructor in Chemistry, Cornell University, Ithaca, N. Y.

Dr. Chas. G. Curtman, 3718 N. 9th street, St. Louis, Mo.

B. B. Goldsmith, Ph.B., Chemist American Lead Pencil Co., 19 E. 74th street.

F. A. Owen, S.B., Chemist Burlington Woolen Co., Burlington, Vt.

The following name was proposed for associate membership: S. V. V. Huntington, Manager Edw. Smith & Co., 158 William street, N. Y.

As a result of a discussion upon the relation of general meetings to regular meetings a motion was made to refer the question to the Board of Directors for consideration and a subsequent report to the Society. Carried. The meeting was then adjourned.

CHAS. F. MCKENNA,
Recording Secretary.

OBITUARY.

SILAS H. DOUGLAS died in Ann Arbor, Mich., August 26, 1890, at the age of seventy-four years. He has been professor of chemistry in the University of Michigan from 1846 to 1877. The chemical laboratory of this institution, erected in 1856 and repeatedly extended, was the product of his labors, continued with energy through the active portion of his life. For a number of years his health has been infirm, and he has remained in the retirement of his devoted family.

ON BLAST FURNACE SLAGS AND THE FUSIBILITY OF SILICATES.

By Augusté J. Rossi.

(*Concluded.*)

An examination of a few specimens of natural silicates occurring as ordinary minerals and of which the composition is very often reproduced artificially in blast furnaces, will corroborate the preceding statement that, in a slag, in a multiple silicate, the silicates of the bases RO and R_2O_3 are of the same type. The following examples are taken from a table of silicates by Prof. Eggleston, of Columbia College, in which the old formula for silica, SiO_3, is used:

*Orthoclase.**—O Ratio, $\begin{matrix} R_2O & R_2O_3 & SiO_3 \\ 1 : & 3 & : 12 \end{matrix}$ or RO, $SiO_3+Al_2O_3$, $3SiO_3$ (Trisilicate of Percy), or, written with SiO_2, $2RO\ 3SiO_2+2R_2O_3\ 9SiO_2$. *Total*—O of SiO_2 : O of bases: : 24 : 8=12 : 4=3 : 1, a *sesqui-acid silicate;* the O ratio for each silicate is 3 : 1 in both formulæ, as for the mineral itself. It is the tri-silicate of the present time derived from $H_4Si_3O_8=2(H_2O)3\ SiO_2$. O ratio 6 : 2=3 : 1.

*Sodalite.**—1 : 3 : 4. $3NaO,\ SiO_3+3(Al_2O_3,\ SiO_3)$. (Tribasic or monosilicate of Percy). Formula, with SiO_2, $2NaO\ SiO_2+2R_2O_3 3SiO_2$. *Bibasic silicate.* O ratio 1: 1 for each silicate, for the compound 12 : 12=1 : 1; derived from $H_4SiO_4=2(H_2O)\ SiO_2$, a monosilicate or orthosilicate with O ratio; 2 : 2=1 : 1.

Anorthite.—1 : 3 : 4. $3CaO,\ SiO_3+3(Al_2O_3,\ SiO_3)$ the same as sodalite, O of acid, : O of bases=3 : 3=1 : 1; or with SiO_2, $2CaO\ SiO_2+2Al_2O_3\ 3SiO_2$ a *bibasic silicate.* O of acid : O

* Found in the United States.

of base=2 : 2=6 : 6=1 : 1 for each silicate and for the compound.

Epidote.—1 : 2 : 3 or $3R_2O\ SiO_3+(R_2O_3\ SiO_3)$; O ratio 1 : 1 the same as sodalite, a *bibasic silicate* $2RO,\ SiO_2+2R_2O_3,\ 3SiO_2$; O ratio of compound 1 : 1, of each silicate 1 : 1.

Garnet.—1 : 1 : 2, $3RO\ SiO_3+R_2O_3SiO_3$. Oxygen ratio 1 : 1 for each silicate and for the compound ; now a *bibasic silicate,* $2RO\ SiO_2+2R_2O_3\ 3SiO_2$ O ratio 1 : 1. Pyrope $3(CaO,\ MgO)\ SiO_3+(Al_2O_3Fe_2O_3)SiO_3$.

Prehnetoid.—1 : 2 : 6, $3RO\ 2SiO_3+2(Al_2O_3\ 2SiO_3)$ (sesquibasic or bisilicate of Percy), O ratio 6 : 3 for each silicate=2 : 1 ; for the compound 18 : 9=2 : 1 ; or with SiO_2 : RO, $SiO_2+R_2O_3 3SiO_2$ a *neutral silicate ;* O ratio of each silicate 2 : 1 ; of the compound 2 : 1. It is monosilicate of modern nomenclature derived from $H_2SiO_4=H_2O\ SiO_2$; O ratio 2 : 1.

Petalite.—1 : 4 : 20, $3RO\ 4SiO_3+(Al_2O_3,\ 4SiO_3)_4$ O ratio for the compound and for each silicate 60 : 15=12 : 3=12 : 3=4 : 1, an *acid silicate,* or with SiO_2 ; RO $2SiO_2+R_2O_3\ 6SiO_2$: O ratio for the compound and for each silicate 16 : 4=12 : 3=4 : 1 ; the disilicate of modern nomenclature derived from $H_2Si_2O_5=H_2O\ 2SiO_2$; O ratio 4 : 1.

Chloritoid.—1 : 2 : 2 : 1 Aq., $3RO\ SiO_3\ \frac{2}{3}+2\ (R_2O_3\ SiO_3\ \frac{2}{3})+3HO$; multiplying by 3 we have $9RO\ 2SiO_3+2\ (3R_2O_3\ 2SiO_3)+9HO$. O ratio compound = 18 : 27=2 : 3. For each silicate 6 : 9 = 6 : 9=2 : 3 ; or with SiO_2 : $3\ RO\ SiO_2+R_2O_3SiO_2$, a *tribasic silicate ;* O ratio for the compound and each silicate=2 : 3 derived from $H_6SiO_5=3(H_2O)SiO_2$; a parasilicic monosilicate ; O ratio 2 : 3.

(*a.*) Assume that we have a slag having a composition corresponding to $RO\ 2SiO_2+R_2O_3 6SiO_2$ an acid silicate of the same type in $RO+R_2O_3$; O ratio for each 4 : 1 ; for compound 4 : 1 ; it corresponds to the following proportions :

1°. SiO_2 = 75.120	We find, *transforming all the bases into lime,*	
(CaO)RO = 8.763	SiO_2	68.19
Al_2O_3 = 16.117	CaO	31.81
100.000		100.00

an acid silicate as we can see from the Table V., O ratio = 4 : 1. The transformation

into lime has *at once* furnished us the type of the silicate without using any formula or symbol.

2°. Let us calculate the formula of this slag by the determination of the oxygen of the constituents : We have

Oxygen.

SiO_2 = 75.120 ..... 40.08 — O of acid = 40.08 = O of bases 10.02 × 4; the type is *acid*. Proportioning the O of silica to that of the bases we find :

CaO = 8.763 ..... 2.507
Al_2O_3 = 16.117 .. 7.521 ..... 10.028

$\frac{2 \times 507 \times 40.06}{10.028} = 10.028$ O of silica in RO, or 5.014 SiO_2 with RO; we have 2.507 O in RO, the formula is 2.507 RO, 5.014 SiO_2.

O of silica in R_2O_3 = 40.08 — 10.028 = 30.05, or 15.025 SiO_2 combined with R_2O_3.

O of R_2O_3 = 7.521 = 2.507 R_2O_3. Formula : 2.507 R_2O_3 15.025 SiO_2 or

2.507 (RO $2SiO_2$) + 2.507 (R_2O_3 $6SiO_2$) a perfect acid silicate of bases in RO and in R_2O_3. O ratio 4 : 1, the same result as obtained by transformation into lime.

3°. Let us calculate the empirical formula from the equivalents :

SiO_2 = 75.120 = 2.50 Eq., or 8.
CaO = 8.763 = 0.313 Eq., or 1.
Al_2O_3 = 16.117 = 0.313 Eq., or 1.

Hence, the *empirical formula* is (RO R_2O_3)$8SiO_2$, and O of silica : O of bases : : 16 : 4 = 4 : 1 as before. The type is an acid silicate as found at once by transformation into lime. But as may be seen, the empirical formula does not furnish any indication as to the grouping of the elements. If we *are to be guided by the oxygen ratio* of the compound, then the only *rational formula* is : RO $2SiO_2$ + R_2O_3 $6SiO_2$ and fatty silicate in RO and R_2O_3 are of the same type.

(*b.*) Let us assume now that we have a substance of the following composition :

R_2O_3 $3SiO_2$ (Neutral) + 2RO SiO_2 (Bibasic). Such a compound may certainly exist, but, if run in a blast furnace, since R_2O_3 $3SiO_2$ as well as 2RO SiO_2 are both refractory or very little fusible, (see fusibility of silicates), let RO be MgO or CaO,

and let R_2O_3 be Al_2O_3; there must certainly be such a combination of the two types, such an exchange of the bases as will no longer correspond to a saturation of $1R_2O_3$ for $3SiO_2$ and of 2RO, for $1SiO_2$, but will furnish a different one corresponding to a unique type or the multiple silicate, and one which must be the same for the bases in R_2O_3 and those in RO.

This formula leads to the following composition:

$SiO_2 = 52.747$
$CaO = 24.615$
$Al_2O_3 = 22.637$

In the table of fusibility, we see that 58 silica, 16 alumina and 26 lime give a *very fusible* silicate. A silicate of the annexed composition would therefore fuse readily in the blast furnace, but if we proportion the silica according to the above formula R_2O_3, $3SiO_2 + 2RO$, SiO_2, we come to

21.10 SiO_2
24.61 CaO

or about 46CaO to $56SiO_2$, the "simple silicate" begins to be barely "fusible," and at SiO_2 31.67, Al_2O_3 22.63, or about 58 SiO_2 to 42 Al_2O_3, the simple silicate is absolutely refractory, it must certainly be then by different saturation of silica to form a unique type that these proportions of silica, lime and alumina furnish a fusible compound.

Transforming *all* into lime, we obtain the following percentage:

$SiO_2 = 46.164.$
$CaO = 53.836.$

(O of acid = 1.6 O of bases) which, falling between a sesquibasic and a neutral silicate (Table V.) represents a sufficiently fusible slag. This transformation gives us at once an approximation of basicity of the slag and the type of the silicate.

3°. If we calculate the formula from the oxygen of the compounds, we find:

O of Silica 28.131
O of RO 7.033
O of R_2O_3 ..... 10.562

15.95

O of acid : O of bases :: 28.131 : 15.95 = 1.6 : 1 as before. If we proportion the O of silica to that of the bases in RO and R_2O_3, we find for the formula:

5.61 SiO_2 7.033 RO + 8.45 SiO_2 3.52 R_2O_3, or 3.52 (R_2O_3 2.4 SiO_2), O ratio 4.8 : 3 = 1.6 : 1 + 5.61 ($1\frac{1}{4}$ RO, SiO_2) O ratio $2 : 1\frac{1}{4} = \frac{8}{4} : \frac{5}{4} = 8 : 5 = 1.6 : 1$ the silicates in RO $2R_2O_3$ are of the same type and of the same type as the compound itself.

R_2O_3, 2.4 SiO_2 is less neutral or *more basic* than R_2O_3, $3SiO_2$ a neutral silicate, but *less basic* than R_2O_3, $2SiO_2$, a sesquibasic silicate; the same for the silicates in RO, the slag as given by the formula falls between a neutral and a sesquibasic slag; just what the trnsformation into lime had given us.

4°. If we calculate the equivalents, we have:

$SiO_2 = 52.747 = 1.758$ Eq. of SiO_2		4
$CaO = 24.615 = 0.879$ Eq. of CaO	or	2
$R_2O_3 = 22.637 = 0.439$ Eq. Al_2O_3		1

The empirical formula is $(2RO, R_2O_3)4SiO_2$. O ratio is $8 : 5 = 1.6 : 1$, just what has been furnished to us by the transformation in lime. But the empirical formula does not afford any means of grouping the elements.

Two types satisfy the condition $(2RO\ R_2O_3)4SiO_2$; they are:

$2RO, SiO_2$ (Bibasic) and $R_2O_3 3SiO_2$ (Neutral), or $2RO\ 3SiO_2$ (Sesquiacid) + $R_2O_3SiO_2$ (Tribasic).

The first corresponds to the formula which has given us the preceding composition, but the second does not, and we have no way to choose *a priori*. If we take as a guide the O ratio, which has been found to be 1.6 to 1 *for the compound*, we reach the preceding formulæ, R_2O_3, $2.4SiO_2 + 1.25RO\ SiO_2$ or $5R_2O_3\ 12SiO_2 + 5RO\ 4SiO_3$. O ratio $= 24 : 15 = 8 : 5 = 1.6 : 1$ for R_2O_3, and the same for the silicate in RO, $8 : 5 = 1.6 : 1$.

(*c.*) Suppose now that we have a slag of the same type in RO and R_2O_3 (Neutral), we are at perfect liberty to admit a composition as follows:

$2(R_2O_3\ 3SiO_2) + 4(RO\ SiO_2)$, as indeed the O ratio: $8 + 12 = 20$ oxygen of acid $: 4 + 6 = 10$ oxygen of bases $: : 2 : 1$ (type neutral), is not changed. It corresponds to:

1°.

SiO_2	= 58.25
CaO	= 21.74
Al_2O_3	= 20.00
	99.99

Calculating the formula we have O of $SiO_2 = 31.06$; O of $RO = 6.21$; $OR_2O_3 = 9.33$; 6.21 (RO, SiO_2) + 3.11 $(R_2O_3\ 3SiO_2)$ a perfectly neutral silicate in RO and R_2O_3. O of silica for each: O of base $: : 2 : 1 : : 6 : 3$.

And 6.21 of neutral silicate in RO : 3.11, of neutral silicate in R_2O_3 : : 4, of neutral silicate in the compound : 2, of neutral silicate in the compound = 2 : 1.

The relative proportion of each is maintained.

2°. Transforming *all into lime* we would have found *at once*, without symbols or formulæ :

$SiO_2 = 58.25$ 58.25
$CaO =$ ..... 21.74 CaO
$Al_2O_3 = 20 \times 1.631 =$ 32.625 CaO

54.365 ..... 54.36

112.61

Or reducing to percentage :

$SiO_2 = 51.72$
$CaO = 48.28$

a typical neutral silicate, Table V.

3°. If we calculate the equivalents, we have :

SiO_2	= 1.941		5
CaO	= 0.776	or	2
R_2O_3	= 0.388		1

And the empirical formula is $(R_2O_3\ 2RO)5SiO_2$, O of silica 10 : O of bases 5 : : 2 : 1 ; the type is neutral.

But if we do not take this as a guide, we can group the bases and the silica in the following manner :

1°. $\underbrace{2(RO\ 2SiO_2)}_{\text{Acid silicate}} + \underbrace{R_2O_3SiO_2}_{\text{Tribasic}}$; or

2°. $\underbrace{2RO\ 3SiO_2}_{\text{Sesquiacid}} + \underbrace{R_2O_3\ 2SiO_2}_{\text{Sesquibasic}}$; or

4°. $2RO\ SiO_2$ (Bibasic) + R_2O_3, $4SiO_2$ (?), and we have no way to choose which is the rational formula. If we adopt the O ratio furnished by the compound, then the *only rational formula* is: $2(RO\ SiO_2) + R_2O_3\ 3SiO_2$, and the silicates in R_2O_3 and in RO are again of the same type; furthermore this gives 2 of silicates in RO for 1 of silicate in R_2O_3, the same proportions

as in the original compound. The transformation into lime has furnished us at once the character of the slag.

We will complete these illustrations by a few examples of slags actually run in blast furnaces, and of which the composition is given in standard books on metallurgy (Percy and others).

Percy gives as the composition of a slag, run in a coke furnace, with hot blast, iron gray :

SiO_2 38.00.....O 20.26. O of acid=very nearly O of bases, *type bibasic.*

Al_2O_3	14.00 ..... 6.53		O of SiO_2 in R_2O_3=6.53 or
CaO	33.50.....9.57	20.09	3.26 SiO_2 (exactly : 3.29)
MgO	6.50.....2.60		O of SiO_2 in RO=13.56 or
MnO	2.50.....0.55	13.56	6.78 SiO_2 (exactly : 6.84).
FeO	2.00.....0.44		The formula is $2RO, SiO_2$(bibasic) $+2R_2O_3$,
K_2O	2.00.....0.40		$3SiO_2$ (bibasic) O of acid : O of bases : 1 : 1.

Established from the O ratio or transformed from the formula in SiO_2, the formula in SiO_3 is (R_2O_3 SiO_3) 2.18+4.52 (3RO SiO_3): O of acid for each silicate: O of base : : 1 : 1; total oxygen of bases=(3×4.52+2.18×3)=20.10; O of acid=(2.18×3+3×4.52)=20.10=O of bases.

Percy gives as an approximate formula: "(R_2O_3 SiO_3+3RO SiO_3)" which is the type formerly called tribasic or monosilicate, now called *bibasic* in SiO_2 : as $3SiO_2$=$2SiO_2$.

This is the mineral called "Mellilite" : 2(3CaO, MgO, NaO) SiO_3+($Al_2O_3Fe_2O_3$)SiO_3. If we had transformed the slag at once into lime we should have found without any formula or symbol :

SiO_2=38.00	38.00	SiO_2
Al_2O_3=14.00×1.631	22.83	CaO
CaO=33.50	33.50	"
MgO=6.50×1.40=	9.10	
MnO=2.50×0.78=	1.95	
FeO=2.00×0.78=	1.56	
K_2O=2.00×0.59=	.24	
	69.18	

Or :	SiO_2	38.00, or in %,	SiO_2=35.45	34.88
	CaO	69.18	CaO=64.55	65.12
		107.10	100.00	100.00

type bibasic.
(Table V.)

Percy gives the composition of a slag from blast furnaces of Olsberg on the Rhine :

		OXYGEN.		
SiO_2	53.76	28.67		O of acid 28.67 : O of bases 15.07 =1.90 : 1, or nearly 2 : 1 *type*
Al_2O_3	4.76	2.22	2.22	*neutral*
CaO	29.48	8.42		O of Silica in R_2O_3=4.35=1.45
MnO	1.30	0.30	12.85	SiO_2
FeO	1.48	0.33		O of Silica in RO=24.32=8.11 SiO_2
MgO	9.50	3.80	15.07	

Formula : 0.74 R_2O_3, 1.45 SiO_3, or, 0.74 (R_2O_3, 2SiO_3)
12.85 RO, 8.11 SiO_3, or, (3RO 1.90 SiO_3) 4.28.

Percy says : Very nearly "(R_2O_3 2SiO_3+3RO 2SiO_3)" or, in SiO_2, RO SiO_2+$R_2O_3$3SiO_2, a neutral silicate in RO and R_2O_3. It is the mineral called *Augite*, containing aluminium silicate, aluminiferous Augite or Pyroxene 3(CaO MgO) 2SiO_3.

Transformed into lime we find at once :

SiO_2=	53.76
Al_2O_3=4.76×1.631 =	7.76 CaO
CaO=	=29.48
MnO=1.30×.78=	1.01
FeO=1.48×.78=	1.15
MgO=9.50×1.40=	13.30
	52.70

Or, SiO_2	53.76	reducing to	SiO_2 =50.50	SiO_2=	51.71
CaO	52.70	percentage	CaO = 49.50	CaO =	48.28
	106.46		100.00		100.00

Very nearly a neutral slag as found before.
O ratio : 2 : 1

We see, from the preceding examination, that in slags corresponding in composition to certain minerals, slags actually run in blast furnaces or in slags made up *a priori* from a given formula, as well as in natural minerals themselves, as quoted from table of such silicates, the individual silicates in RO and R_2O_3, have been found to be of the same type, which is the type of the compound itself characterized by a certain *ratio of the total oxygen of* SiO_2 *to that of the bases.* Whatever may be the relation of the oxygen of the bases in RO, to the oxygen of the bases in R_2O_3, if it is rational to say that the amounts of silica combined with each class of oxide must bear a certain relation to the quantities of oxygen contained in each, we are then justified in dividing the oxygen of the silica proportionally to these numbers. By so doing we must find constantly as the quota of oxygen of the silica combined with the bases RO and R_2O_3, figures which will give for the silicates of RO and R_2O_3 a ratio of O of acid to O of the base precisely the same as that of the compound itself, since in each case the calculation is established as follows: Total O of silica = m, O of RO = a, O of R_2O_3 = b, and total O of bases = a + b. Ratio of the total O of SiO_2 to total O of bases in the compound = $\frac{M}{a+b}$.

O of silica combined with $R_2O_3 = \frac{M \times b}{a+b}$

O of silica combined with

$$RO = M - \frac{Mb}{a+b} = \frac{Ma + Mb - Mb}{a+b} = \frac{Ma}{a+b}$$

and $\frac{Ma}{a+b}$ O of silica as silicate of RO : a O of RO = $\frac{M}{a+b}$

$\frac{Mb}{a+b}$ O of silica as silicate of R_2O_3 : b O of $R_2O_3 = \frac{M}{a+b}$

the O ratio of the compound itself.

The rational formula of a silicate cannot be established otherwise than by taking as a guide the O ratio, the only clear and indisputable character furnished directly by the analysis. The use of the equivalents or atomic weights, as we have seen, gives an *empirical*

formula which allows of the grouping of the constituents in different manners; some of them not corresponding at all with the formula of the compound taken as basis of composition *a priori*.

For example: A slag run with white iron calculated in equivalents gave

$$(\text{Silica as } SiO_3),\ (3RO\ R_2O_3),\ 4SiO_3.$$

It can be grouped as follows:

O ratio 12 : 6 or 6 : 3 = 2 : 1 *Neutral*

$$(a.)\quad \underbrace{3(RO\ SiO_3)}_{\text{Trisilicate of Percy.}} + \underbrace{R_2O_3\ SiO_3}_{\text{Monosilicate of Percy.}} \qquad (b.)\quad \underbrace{3RO\ SiO_3}_{\text{Monosilicate of Percy.}} + \underbrace{R_2O_3\ 3SiO_3}_{\text{Trisilicate of Percy.}}$$

and, lastly, if the oxygen ratio is taken as a guide

$$(c.)\quad \underbrace{3RO\ \ 2SiO_3}_{\text{Bisilicate of Percy.}} + \underbrace{R_2O_3\ \ 2SiO_3}_{\text{Bisilicate of Percy.}},\ \text{or}\ RO\ SiO_2 + R_2O_3\ 3SiO_2$$

a neutral silicate in RO and R_2O_3.

In all cases, whether the *empirical* or the *rational* formula be adopted, we can obtain immediately, without the use of any symbol, by a simple multiplication and reduction to a percentage, all the elements necessary to judge of the "basicity" of a slag, of its approximation to certain types, and consequently of its fusibility as well as all the data for comparison with any other of different composition. All that is necessary is to transform all the bases into their equivalent in lime, as has been explained.

By such transformation we do not alter in any manner the type of the silicate, its oxygen ratio.

The characteristic feature of a silicate being afforded by the proportion of the oxygen of the acid to that of the base, if, in such a compound, a neutral silicate for instance,

$$SiO_2 = 51.72$$
$$RO = CaO = 48.28$$
$$\text{O ratio } 2 : 1$$

the quantity of R^1O (magnesia for example) which replaces a certain quantity of lime bears a direct proportion to their saturation for SiO_2, which, for this class of oxide MO, is as to that of their equivalent R^1O and RO, it is evident that the silicate *will pre-*

serve its type, the oxygen ratio of the silica remaining the same and being still double that of the base.

This can be established in an absolutely general manner as follows :

1°. Let

$$SiO_2 = a$$
$$CaO = RO = b$$

be a regular type of silicate of any kind for which *we know* that

O of silica = k, O of base. O of $SiO_2 = \frac{8}{15}a$. O of $CaO = \frac{2}{7}b$,

and we have, as characteristic of the compound,

$$\frac{8}{15}a = \frac{2b}{7} \times k.$$

Let us first replace any part b′ of the weight b of lime by a weight b″ of MgO, saturating the same quantity of silica as b′ of lime, thus b″ magnesia : b′ lime : : 20 equiv. of MgO or 40 atomic weight of MgO : 28 eq. of lime or 56 atomic weight of lime

$$= 5 : 7 \qquad \frac{b''}{b'} = \frac{5}{7}; \quad b'' = \frac{5}{7}b',$$

the composition of the silicate may be written then :

$$SiO_2 = a$$
$$CaO = b - b'$$
$$MgO = b'' = \frac{5}{7}b'$$

the O of the silica in the new compound

$$= \frac{8}{15}a = \frac{2b}{7} \times K$$

as above. O of bases $= \frac{2}{7}(b - b')$ O of lime $+ \underbrace{\frac{2}{5} \times \frac{5b'}{7}}$ O of MgO

$$\text{O of bases} : = \frac{2b}{7} - \frac{2b'}{7} + \frac{2b'}{7} = \frac{2b}{7}$$

O of acid $= \frac{2b}{7} \times k =$ O of bases $\frac{2b}{7} \times k$ as before. The silicate *has maintained its type,* whatever it may have been originally, and whatever may have been the quantities a, b, k, b′, b″.

2°. But if we replace the total weight b of lime by any weight b′ of CaO and b″ of MgO, such that $b' + b'' = b$, the composition of the silicate becomes

$$\begin{aligned} SiO_2 &= a \\ CaO &= b' \\ MgO &= b'' = b - b' \end{aligned}$$

the O of silica is always

$$\frac{8}{15} a = k \frac{2b}{7}$$

$$\text{The oxygen of the bases} = \frac{2}{7} b' + \frac{2}{5}(b - b') = \frac{2b'}{7} + \frac{2b}{5} - \frac{2b'}{5} =$$

$$\frac{10b' + 14b - 14b'}{35} = \frac{14b - 4b'}{35}$$

Let b′ be any part whatosever of $b = \frac{mb}{n}$ we have then :

$$\text{O of bases} = \frac{14b - 4b'}{35} = \frac{14b - 4 \times \frac{mb}{n}}{35} = \frac{14bn - 4mb}{35n} = \frac{2b}{7} \times \frac{7n - 2m}{5n}$$

and, O of acid :

$\frac{2b}{7} \times k$ is no longer equal to $=$ O of bases $\frac{2b}{7} \times k$; *the type is changed,*

but, if $\frac{7n - 2m}{5n} = 1$ we return to the original silicate, this will happen if $n = m$.

$m = 1$ then $\frac{7n - 2m}{5n} = \frac{7m - 2m}{5m} = 1$; $b = b'$ and the composition becomes

$$\left.\begin{aligned} SiO_2 &= a \\ CaO &= b \\ MgO &= b - b' = b'' = 0 \end{aligned}\right\} \text{O of acid } \frac{2b}{7} \times k = \text{O of bases } \frac{2b}{7} \times k \text{ as}$$

it should be.

3°. In the same manner if in the silicate $\begin{cases} SiO_2 = a \\ CaO = b \end{cases}$ we replace b' of lime by a weight b'' of alumina equivalent as saturation for silica (see Table III. *a*) $= \dfrac{b'}{1.631}$

We have for the new composition $\begin{cases} SiO_2 = a \\ CaO = b - b' \\ Al_2O_3 = \dfrac{b'}{1.631} = b'' \end{cases}$

This number 1.631 has been obtained by the consideration that for saturation of silica, for the same type (neutral) $1RO = 28$ saturates $1SiO_2 = 30$ or $3RO = 84$ saturate $3SiO_2 = 90$, while $1Al_2O_3 = 51.50$ saturates $3SiO_2 = 90$. Hence: 84 lime are equivalent to 51.50 Al_2O_3, since they saturate the same quantity 90 of SiO_2.

Hence: 1 lime $= \dfrac{51.50}{84} Al_2O_3$ or $1Al_2O_3 = \dfrac{84}{51.50} = 1.631$ CaO.

$$1.631 = \frac{84}{51.50}$$

and we have: $b'' = \dfrac{b'}{\left(\dfrac{84}{51.50}\right)} = \dfrac{b' \times 51.50}{84}$. The composition of the silicate can then be written:

$$\left.\begin{matrix} SiO_2 = a \\ CaO = b - b' \\ Al_2O_3 = b' \times \dfrac{51.50}{84} \end{matrix}\right\}$$

$$O \text{ of bases} = \underbrace{\frac{2}{7}(b-b')}_{CaO} + \underbrace{\left\{ b' \times \frac{51.50}{84} \right\} \times \frac{24}{51.50}}_{O \text{ of } Al_2O_3} = \frac{2b'}{7}$$

$$\left\{\frac{2b}{7} - \frac{2b'}{7}\right\} + \frac{24b'}{84} = \frac{2b}{7} - \frac{2b'}{7} + \frac{2b'}{7}$$

$$\text{O of acid} = \frac{8}{15}a = \frac{2b}{7} \times k$$

$$\text{Total O of bases} = \frac{2b}{7} - \frac{2b'}{7} + \frac{2b'}{7} = \frac{2b}{7} \text{ and}$$

$$\text{O of acid} = \text{O of bases} \frac{2b}{7} \times k \text{ as before, the type has not been}$$

changed.

Let us calculate the formula of the compound in this case.

$$\text{O of RO} = \frac{2b-2b'}{7}; \quad \text{O of } R_2O_3 = \frac{2b'}{7}$$

$$\text{Total O of acid} = \frac{8}{15}a = \frac{26}{7} \times k.$$

$$\text{Total O of bases} = \frac{26}{7} = \begin{cases} \text{O, O of RO} = \dfrac{2b-2b'}{7} \\ + O_3, \text{ O of } R_2O_3 = \dfrac{2b'}{7} \end{cases}$$

$$\text{O of acid } \frac{2b}{7} \times k = \text{O of bases } \frac{2b}{7} \times k.$$

Proportioning the O of SiO_2:

$$\text{O of silica combined with RO} = \frac{\left\{\dfrac{2b}{7} \times k\right\}(2b-2b')}{\dfrac{2b}{7}} = k\left\{\frac{2b-2b'}{7}\right\}$$

$$\text{O of silica combined with } R_2O_3 = \frac{2b}{7}k - k\left\{\frac{2b-2b'}{7}\right\} = k \times \frac{2b'}{7}$$

and formula is:

$$\left\{\frac{2b-2b'}{7}\right\} R,\ k\left\{\frac{2b-2b'}{7}\right\} Si\ ;\ \text{O of acid } k\left\{\frac{2b-2b'}{7}\right\} =$$

$$O \text{ of bases } \left[\frac{2b-2b'}{7}\right] \times k \left[\frac{2b'}{7}\right] R_2,\ k \left[\frac{2b'}{7}\right] Si;$$

$$O \text{ of acid } k \left[\frac{2b'}{7}\right] = O \text{ of base } \left[\frac{2b'}{7}\right] \times k$$

The silicates in RO and R_2O_3 are of the same type as $k \times O$ of base and of the same type as the compound itself.

We could prove in the same manner that if the weight b″ of Al_2O_3 were not equivalent for saturation of silica to that of the lime it replaces in the compound, the type of the silicate, the oxygen ratio, is changed, but remains the same for the silicates in RO and R_2O_3 as the new ratio of the compound itself.

Hence: Let a slag be expressed with SiO_2 or SiO_3, as the symbol for silica; let the equivalents or the atomic weights be used, the empirical or rational formulæ, the nomenclature neutral, e. g., sesquiacid, sesquibasic-----slag, or the more modern names derived from hypothetical radicals be employed; in all cases the oxygen ratio remains the same, as it should be. This ratio constitutes, so to speak, the individual feature of a silicate, it decides as to its greater or lesser fusibility, its possible coexistence with certain grades of iron, and, since the transformation of all the bases into their equivalent of lime does not modify it in any manner, as we have just seen, we possess, then, in this method an absolutely exact and easy mode of comparison of two slags. No notation or symbol of any kind is required; we have to deal only with *figures* representing the composition of the substance as given by the analysis itself; the relative character of two silicates can be judged at once, the tables of references furnishing all the other data pertaining to each case.

Calculation of Slag.—This method of transformation of all the constituents into lime will be found very advantageous in calculating a slag. It simplifies the work considerably, and from the beginning to the end the operations can be performed by a non-technical person without using any symbol or formula.

Assume that we have a mixture of ores, of which the average composition is:

Ore.		Limestone.		Ashes of Coal.	
SiO_2	20.00				
Al_2O_3	3.20				
CaO	3.10				
MgO	2.60	We use a limestone of composition:	SiO_2 6.00	And anthracite coal with 6.28% ash, of which ash the composition in per ct. of *coal* is	SiO_2 3.35
O of iron	70.00		Al_2O_3 1.15		Al_2O_3 2.73
Mn_3O_4	0.20		CaO 30.00		CaO 0.10
P_2O_5	1.05		MgO 19.00		MgO 0.10
S	0.10		CO_2 44.30		6.28%
	100.25	Metallic iron, 50%	100.35		

We have decided to obtain a slag of such a character that the fusibility will be about that of a *sesquibasic slag*, that is, if preferred, of one in which O ratio is 4:3. Looking at the table we see that, for such a type, 1 of lime saturates 0.714 of silica, or 1 of silica takes up 1.400 of lime. Assuming any proper amount of coal per ton of ore smelted and, in most cases, 0.75 ton is all that is required, we have all the data necessary for our calculations. Transform *all the analyses into lime:*

Ore.

$SiO_2 = 20.00\%$ ---------- 20.00
$Al_2O_3 = 3.20 \times 1.631 = 5.22\%$
$CaO = 3.10 = 3.10$ } = 12.11% CaO
$MgO = 2.60 \times 1.40 = 3.64$
$Mn_3O_4 = 0.20 = .15$

The *ore* is equivalent per ton to { $SiO_2 = 20.00\%$; CaO = 12.11%

Stone.

SiO_2 = ---------- 6.00
$Al_2O_3 = 1.15 \times 1.631 = 1.87$
$CaO = 30$ ---------- $= 30.00$ } 58.47% Lime.
$MgO = 19 \times 1.40$ -- $= 26.60$

The *stone* is equivalent per ton to { SiO_2 6.00%; CaO 58.47%

Coal.

SiO_2 = ---------- 3.35%
$Al_2O_3 = 2.73 \times 1.631 = 4.45$
CaO ---------- $= 0.10$ } CaO
MgO ---------- $= 0.14$

The *coal* is equivalent per ton to { SiO_2 3.35%; CaO 4.69%

Hence, as we use only $\frac{3}{4}$ ton of coal per ton of ore, the coal used is equivalent to $\frac{3}{4}$ of the above analysis, or:

SiO_2 ---- 2.52
CaO ---- 3.52

$SiO_2 = 20 + 2.52 = SiO_2$ --- 22.52

per ton of ore; the coal and ores are equivalent to $CaO = 12.11 + 3.52 = CaO$ -- 15.63. Since, to make the proper silicate, 1 of lime

takes up 0.714 of silica, the 15.63 of lime in coal and ores will take up: $0.714 \times 15.63 = 11.16\%$ of silica, leaving as *free silica* in the ore and coal $22.52 - 11.16 = 11.36$ SiO_2 to saturate with limestone. The 6% of *silica of the stone* will require, at the rate of 1.400 lbs. lime per lb. of SiO_2, $6 \times 1.40 = 8.40$ lime, leaving of *free lime* or the equivalent in the limestone, $58.47 - 8.40$ or 50.07 *free lime.* We have to saturate in coal and ores, 11.36 free silica. At the rate of saturation adopted, it will take: 11.36×1.40 lime $= 15.91$ lime; we have 50.07 free lime in 1 ton of limestone, we require only 15.91 of lime to *saturate the* SiO_2 in coal and ores, hence, we need only *per ton of ore and* $\frac{3}{4}$ *ton coal,*

$$\frac{15.91}{50.07} = 0.317$$

ton of stone. *The charges* are thus: 1 ton of ore, 0.75 ton of coal, 0.317 ton of limestone and, as the ore contains *50% of iron, we require:*

2 tons ore
1.50 tons coal
0.634 ton stone
} *per ton of pig made.*

The composition of the slag is:

Silica in ore and coal per ton of ore and per $\frac{3}{4}$ ton of coal	22.520
In stone 6×0.317 ton	1.908
Total SiO_2	24.428
Lime in $\frac{3}{4}$ ton coal and 1 ton ore (per ton ore)	15.63
In stone 0.318 ton $\times$ 58.47%	18.59
Total lime	34.22

and composition of slag is:

SiO_2	24.428	or reducing to a	SiO_2 = 41.66
CaO	34.220	percentage:	CaO = 58.34
	58.648		100.00

exactly a sesquibasic silicate. See Table V.

Using the preceding charges of ores, stone and coal we should have every reason to expect a slag of the above composition or of one very close to it.

We have adopted 1½ ton coal per ton of pig. If it were found that this could be reduced it should be done and the slag would hardly be modified in general character by this charge. If greater accuracy were necessary the preceding calculations could be made over again with the *new charges* in coal; but, practically, it is absolutely useless, the ash of coal entering, as it may be seen, as a small percentage into the general composition. With inferior cokes or anthracite it becomes an important factor *not to be neglected* but *too often ignored*. Cokes with 15% of ash are not uncommon in certain localities.

As an example of the close coincidence between slags actually run from known calculated charges and the slag determined *a priori* we quote the following slag run in a furnace 60 feet high, 16 feet bosh, running on hot blast 850 to 900° F. Pressure of blast 7½ lbs., American furnace, anthracite coal. The analyses of materials were as follows :

	Ores.	Stone.	Coal.
SiO_2	23.31	9.90	3.00
Al_2O_3	4.51	3.88	2.30
CaO	1.61	28.00	0.10
MgO	3.41	16.00	0.08
Alkalies	2.67	----	----
Mn_3O_4	traces	----	----
P_2O_5	0.31	----	----
S	0.08	----	----

Making the calculations proportionally to the quantity of the different materials charged, we find that the slag contained :

	Metallic iron 46.46%.	New Jersey Dolomite.	Lehigh Summit.
Charges :	8cwt. 1q 0lb.	3cwt. 1q 14lbs.	5—1—0
	924 lbs.	378 lbs.	588 lbs.

	Ores.	Stone.	Coal.	Total.
Silica	215.38	37.42	17.64	270.44 lbs.
Alumina	41.67	14.66	13.52	69.85 "
Lime	14.90	105.84	0.59	121.33 "
Magnesia	31.50	60.48	0.47	92.45 "
Alkalies	24.67	----	----	24.67 "
Mang. oxide	Traces	----	----	---- "
Total weight of slag				578.74 lbs.

924 lbs. of ore gave in iron 425 lbs., the ores having 46.60% Fe. With such slag, of which the character was sesquibasic, a light grade of iron was to be expected, such pig as contains in an average 1.50% silicon or 3.20% silica corresponding, in 425 lbs. of pig iron, to 13.60 lbs. of silica, which, subtracted from the total silica which went to form slag and pig, leaves a balance of 256.84 lbs. SiO_2 to be expected in slag. The composition of the slag was then :

Calculated.		Per Cent.		The analysis gave:	
SiO_2	256.84	SiO_2	45.44	SiO_2	44.27
Al_2O_3	69.85	Al_2O_3	12.36	Al_2O_3	12.91
Lime	121.33	CaO	21.40	CaO	20.00
MgO	92.45	MgO	16.36	MgO	16.50
Alkalies	24.67	Alk	4.40	Alkalies	3.98
				Ox. of iron	2.47
	565.14		99.96	MnO	Traces
				S	0.56
					100.69

This quantity of iron, 2.47% is not abnormal, but occurs in many slags. If we take it into consideration in calculating the slag we have 99.96 + 2.40 = 102.36. Reducing to a percentage we find :

Calculated Slag (iron added).		*Actual Analysis.*
SiO_2	44.34	44.27
Al_2O_3	12.06	12.91
CaO	20.88	19.81
MgO	16.00	16.50
Alkalies	4.22	3.98
Ox. iron	2.47	2.47

The iron was found to be No. 3 light gray, containing 1.53 silicon. Transformed into lime, this slag corresponds to :

SiO_2	40.66
CaO	59.34
	100.00

A typical sesquibasic slag has for its composition :

SiO_2	41.66	Table V.
CaO	58.34	
	100.00	

But, if *we neglect* the 2.47% of iron *not taken into consideration in the first calculations* we find when transformed into lime:

SiO_2 41.65
CaO 58.36 } for the composition of the "calculated slag."

Having explained how to obtain the formulæ of slags with the symbols SiO_2 or SiO_3 for silica and how to transform the old formula into the new one or inversely, and possessing now, for all cases, an easy and rapid method of comparison of two slags, by transforming all the bases into lime, without using any chemical symbols, or making any hypotheses as to their composition, we shall proceed to the critical examination of a number of slags for which we know, at least and with certainty the grade of iron accompanying them, to see if the general statement that as the slag is more basic the tendency of the iron is to be of a darker grade, finds itself corroborated by blast furnace practice.

We give first the full analyses of the slags, as they were given by the different writers, or as they were obtained by us, many of them having been made by ourselves, completing them by a succinct description of the furnace from which they were run, and of the circumstances of their production as nearly as we have been able to ascertain them. For many slags we have also the analyses of the ores, stone and coals, and the charges, but they do not figure in this paper. In the transformation of the slags into lime, we have often stopped the operations at the first decimal; it is a sufficient approximation for a study of such compounds.

TABLE VI.—ANALYSES OF SLAGS.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14
SiO_2	46.37	45.23	38.48	43.40	70 23	53.79	49.57	48 39	41.11	37.84	45.64	41.11	39.95	40.20
Al_2O_3	4.30	14.30	15.13	12.20	6.37	13.04	9.00	6 66	13.45	13.20	10.84	9.46	17.41	16.45
CaO	38.64	32.09	32.82	18.13	20.41	25.67	.....	.....	29.82	20.68	35.01	37 50	29.64	30.00
MgO	7.40	3.78	7.44	4.50	.....	0.57	15.15	10.22	4.75	2.93	3.16	2.11	6.47	7.29
MnO	1.86	1.02	1.62	5.80	2.70	2.20	25.84	33.96	0.66	0.80	traces.	1.61	0.91	0.84
FeO	0.95	3.03	0.76	10.99	0.15	2.44	0.04	0.06	6.44	20.83	0.71	0.38	0.24	0.57
K_2O	0.30	1.55	1.92	.....	.....	.....	.....	.....	Alk.	Alk.	Alk.	Alk.	Alk.	
Na_2O	0.14	.....	.....	.....	.....	.....	.....	.....	1.84	1.08	0.82	0.71	1.46	1.30
S	0.03	CaS_2 1.87	Sulp Ca 2.22	CaS_2 3.97	.....	.....	.....	.....	S. Calc. 1.34	S. Cal. 1.77	S. Calc. 3.30	S. Calc. 6.41	S. Cal. 3.60	2.71
P_2O_5	traces	.....	0.15	.....	.....	.....	.....	.....	.....	traces.	traces.	traces.	traces.	traces.
Character of Iron	Gray No. 3.	White.	Foundry Gray.	Gray.	Gray.	Mottled.	Gray.	White.	White.	White.	Gray.	Gray No. 2.	Gray No. 2.	Gray No. 2.
Bl. Furnaces	Edsken Sweden	Dowlais England.	Dowlais England.	Westphalia.	Sweden	Sweden	Sweden	Spiegeleisen.	English	English	English Dowlais	English Dowlais	English Aberdare.	English Aberdare.

TABLE VI.—(*Continued.*)

	15	16	17	18	19	20	21	22	23	24	25	26	27	28
SiO_2	41.64	42.94	36.80	48.42	29.25	37.80	40.10	40.50	37.99	38.26	39.30	39.71	49.57	47.39
Al_2O_3	13.20	16.29	13.80	7.56	19.25	13.70	10.40	9.90	14.33	9.28	11.28	18.96	9.00	6.66
CaO	35.91	31.10	46.00	27.89	38.25	48.50	49.30	49.50	47.66	39.50	43.84	35.26	.....	.....
MgO	4.21	4.16	2.54	6.48	0.60	.....	.....	.....	.....	.....	.....	0.66	15.15	10.22
MnO	0.74	0.51	.....	6.37	8.76	.....	.....	.....	.....	.....	.....	0.62	25.84	33.96
FeO	0.11	0.34	.....	4.39	1.04	.....	.....	.....	.....	.....	.....	0.887	0.04	0.06
K_2O	Alk.	Alk.	Alk.	.....	.....	.....	.....	.....	.....	.....	.....	Alk. 0.98	.....	.....
Na_2O	0.70	1.87	0.86	.....	.....	.....	.....	.....	.....	.....	.....	Cu.0.083	.....	.....
S	Ca. S. 2.19	Ca. S. 2.16	.....	.....	2.16	.....	.....	.....	.....	.....	.....	Ca. S. 2.85	0.80	.....
P_2O_5	traces.	traces.	.....	0.02	SiO_2 0.75	.....	.....	.....	.....	.....	.....	traces.	.....	.....
	Gray No. 2. Aberdare, English	Gray No. 2. Aberdare, English	Gray. Tonlaw English	Gray, Light and Mottled Sweden	Gray, 1, 2 to 3. Cleveland, England.	Gray. Bessèges, Belgium.	Gray. Bessèges, Belgium.	Gray & Mottled Bessèges, Belgium.	Gray. Bessèges, Belgium.	Gray. Prussian, Westphalia.	Gray & Mottled Prussian, Westphalia.	Gray. Aninan Austrian.	Gray. Hamm.	White. Hamm.

TABLE VI.—(*Continued.*)

	29	30	31	32	33	34	35	36	37	38	39	40	41	42
SiO_2	52.80	57.00	45.40	37.80	36.60	32.65	35.00	35.40	39.00	41.85	39.07	44.87	39.48	36.59
Al_2O_3	3.40	10.60	4.60	2.10	18.40	23.00	19.70	15.00	14.10	14.73	9.32	9.14	8.35	8.22
CaO	5.60	5.60	4.20	.....	35.80	31.00	29.90	48.00	44.00	30.99	45.59	23.37	29.81	39.68
MgO	9.00	13.80	8.60	8.60	4.80	0	.....	0.50	1.00	4.76	3.17	14.13	13.31	9.25
MnO	26.20	5.40	33.40	29.20	.....	4.20	8.20	.....	1.00	1.24	0.80	0.99	1.94	2.04
FeO	1.40	6.80	1.80	21.50	2.00	2.00	1.00	.....	1.40	2.63	0.80	3.42	3.01	2.12
K_2O	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	Alk 0.23	Alk	Alk	Alk
Na_2O	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	BaO 0.40	3.50	3.37	1.62
S	.....	.....	.....	0.02	1.00	.....	.....	1.80	1.20	Sul Calc 2.07	SiO_2 *	0.58	0.73	.....
P_2O_5	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
	White. Müsen.	Mottled White. Müsen.	White. Müsen.	Hamm White.	Gray. Terre-noire, France.	Scotch Gray No. 1.	Scotch Gray Nos. 2 to 4.	Bessè-ges. Gray Graph-itic. Bel-gium.	Bessè-ges. 20% P. Cinders Gray.	Mottled and White. Dowlais Eng-land.	Gray No.1& 2 Colora-do, ¼ Puddled Cinders contain-ing 10% SiO_2.	White. N. J. Ameri-can.	White. N. J. Ameri-can.	Gray. N. J. Ameri-can.

TABLE VI.—(*Continued.*)

	43	44	45	46	47	48	49	50	51	52	53	54	55	56
SiO_2	40.17	43.22	50.10	35.48	44.28	47.16	45.98	47.89	43.07	48.16	43.55	45.71	48.50	48.35
Al_2O_3	6.59	9.11	8.26	10.26	8.02	10 41	10.17	9.24	8.80	9.14	10.84	13.19	12.05	12.74
CaO	36.10	36.08	27.04	35.79	37.58	23.30	25.15	22.52	28.30	27.17	28.20	30.26	25.41	23.83
MgO	8.60	7.92	9.40	9.80	9.01	15.79	15.99	15.63	13.22	9.51	12.70	6.96	10.70	10.71
MnO	3.47	0.82	0.02	2.54	0.92	1.85	1.85	2.10	2.27	1.22	1.05	0.29	0.52	0.63
FeO	3.06	1.02	4.88	3.73	2.16	0.28	traces	traces	2.65	3.80	1.68	2.31	1.74	1.58
K_2O	Alk	Alk	Alk	Alk	.....	Alk	Alk	Alk	Alk	Alk	Alk	Alk	Alk	Alk
Na_2O	1.62	1.79	.....	1.94	.....	0.93	0.64	1.57	1.05	0.60	2.00	1.38	0.25	0.33
S	0.39	0.59	.....	0.46	0.45	0.45	0.28	0.12	0.64	0.41	.....	.....	0.82	0.82
P_2O_5	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
	Gray.	White and Mottled	White.	White Chro-mium.	Mottled	White.	White.	White.	Gray No. 2.	White and Mottled	Gray.	Light Gray No. 3.	White.	White and Mottled

*All American furnaces.

*All American furnaces.

TABLE VI.—(*Concluded.*)

	57	58	59	60	61	62	63	64	65	66	67	68	69	70
SiO_2	42.80	39.15	42.64	40.97	43.19	46.80	43.36	40.45	42.77	46.04	46.11	44.27	42.77	35.48
Al_2O_3	9.76	10.32	13.48	11.31	16.33	13.69	16.92	8.90	11.90	12.05	11.89	12.91	11.93	10.26
CaO	28.52	32.76	27.75	30.30	24.73	21.28	23.67	28.89	23.26	21.88	21.66	19.81	23.26	35.79
MgO	14.55	14.27	12.89	13.77	12.85	14.75	13.91	15.65	16.78	16.28	14.80	16.50	16.78	9.80
MnO	1.05	0.35	0.20	0.10	traces.	traces.	traces.	3.01	traces.	0.30	traces.	traces.	traces.	2.54
FeO	1.99	1.61	2.12	1.88	1.55	1.18	0.99	0.99	0.80	1.28	1.75	2.47	1.39	3.73
K_2O	Alk.	Alk.	Alk.	Alk.	Alk.	Alk.	Alk.	Alk.	Alk.	Alk.	Alk.	Alk.	Alk.	Alk.
Na_2O	0.60	0.79	0.12	0.79	0.69	1.69	0.50	1.13	3.44	1.68	2.91	3.48	3.44	1.94
S	0.73	0.75	0.90	0.88	0.66	0.51	0.68	0.98	0.64	0.54	0.55	0.56	0.57	0.46
P_2O_5	.....	.....	.....	.....	.....	.....	.. .	.....	... .	.....	.....	.....	.....	Gray No. 1.
	Mottled	Gray No. 2x.	Gray.	Gray No. 1.	Gray No. 2.	Gray No. 2 and 3.	Gray No. 3.	Gray No. 2.	Gray No. 2 and 3.	No. 3 and Mottled	Mottled	Gray No. 3, Light.	Gray No. 3.	Gray No. 1.

All American furnaces.

(1.) Edsken, Sweden.—Hot blast, 572° Farh.; height of furnace, 44′ to 48′; boshes, 7′4″; blast, $0^{k}.07$ to $0^{k}.105$; average, 0.0875 ky. per □ centimetre = 1.20 lbs. per square inch; very fluid slag.

(2.) Dowlais furnace.—Ores, mixture of argillaceous carbonates and hematites; iron run; generally gray No. 2 and No. 3.

(3.) Dowlais furnace. (4.) Westphalia slag, leek green, the quantity of FeO, 10.99%, is remarkably high; vitreous and conchoidal fracture. (5.) Argillaceous ores, enamel like, bluish white, wood furnace, Sweden. (6.) Swedish furnace, wood as combustible, green and vitreous slag; spathic carbonates and brown hematites; air *very hot*. (7.) Spiegeleisen. (8.) Do. Spiegeleisen Swedish furnace. (9.) Hot blast, Dowlais. (10.) Cold blast, English. (11)–(12.) Argillaceous ores; pisolithic ores and puddle cinders. (13)–(14.) Aberdare B. furnaces, argillaceous ores, cold blast. (15)–(16.) Aberdare furnaces, hot blast 315° C. (17.) Coke furnace, Tonlaw. (18.) Lake and bog ores, cold air 0.07 kilo. per cm_2, Tinspong, Sweden, charcoal furnace. (19.) Manganiferous ores containing 37.19% mang. oxide, Cleveland furnace. (20.) Bessèges, Belgium, hot blast 536° Farh.: pressure, $0^{m}.12$ to $0^{m}.14$. (21)–(22)–(23.) Do. (24)–(25.) Berge Borbeck furnace, hematites and argillaceous ores, poor; average, 35% iron; coke furnace, 47′ ft. high x 15′6″ boshes; crucible, 5′3″ diam.; temperature of air, 180° C.; pressure, 0.16m. mercury per square centimetre. (26). Austrian furnace, hematites and magnetites; hot blast; pressure, 0.069m. mercury; coke furnace, height 48′; boshes, 13′6″; hearth, 3′4″; temperature blast, 150°C.; pressure in lbs., 2½ to 3 lbs. (27.) Hamm furnace slag, manganiferous ores; manganese oxide in slag 25.84%. (28.) 33.96% MnO in slag. (29.) Müsen furnace, Spiegeleisen 26.20% MnO in slag. (30.) Müsen slag, 6.80 FeO in slag, 540 MnO. (31.) Do., Spiegeleisen MnO in slag 33.40%. (32.) Cold blast Hamm furnace, slag containing 29.20% MnO and 21.50 FeO. (33.) Terrenoire (France). (34.) Scotch iron. (35.) Do. (36)–(37.) Bessèges (Belgium) furnaces, 20% puddle cinders added to charges for slag, No. 37. (38.) English slag, Dowlais furnace; average. (39.) Slag from Colorado furnace; Hot Spring and Calumet ores, mixture of

rich magnetites 58% iron; and rich hematites 45% iron; Bessemer ores 25%, puddle cinders containing 9.47% titanic acid added regularly to the charges. Iron No. 1 and No. 2 Foundry, very tough; coke furnace 70 ft. high, 18% ashes.

(40.) Magnetite ores from New Jersey, very rich, general average, 50 to 55%. Iron, with gangue of free silica, hornblende, iron mica, furnace 45 feet high. Anthracite. Pressure of blast 3½ lbs. per square inch; temperature, 750 to 800° F. (41.) Same ores, with a mixture of one-half Staten Island hematite, containing 1.25% chromium, which went into the iron making it white and hard. (42.) Half Staten Island hematite, half New Jersey magnetites, chromium in the pig iron, 1.10%. (43.) All New Jersey magnetites. (44.) Do. (45.) Do.; ores very silicious at the time, containing as much as 40% hornblende and iron mica, the furnace being only 45 feet high, they did not have time to be reduced, got into the hearth, fused and passed out as slag, which explains the anomaly of such an acid slag in connection with a gray forge iron. (46.) Staten Island hematites added to the charges, making the iron white; chromium in the iron, 1.20%. (47.) Regular N. J. hematites. (48)–(49)–(50.) Do. (51.) Same ores, but furnace 60 feet high; pressure of blast, 6 to 7 lbs.; temperature, 800 to 900° Fahr. (52) to (70.) Do.

Average charges for Pig, 1.00.

Ores,	2.00.	New Jersey magnetites generally.
Stone,	1.00.	New Jersey dolomites.
Coal,	1.50.	Lehigh anthracite and Scranton.

To compare these slags we have to transform them all into lime, and, as the approximations of a type to "basicity" is more logically expressed by the quantity of lime, we shall tabulate *only* the quantity of lime (calculated in some cases to only one decimal) to which all of the basic elements of the slags are equivalent. As some of the results fall between two types, the slag of the type to which it comes the nearest will determine the designation. An acid slag containing 31.80% CaO and the next type, the sesquiacid,

38.35% CaO; (see tables) any slag which contains a quantity of lime greater than the average $=\frac{38.35+31.81}{2}=35.08\%$ of lime will be tabulated as *sesquiacid*, if *less* as an *acid* slag. Any slag containing a quantity of lime greater than *43.31%*, the average of 38.35 (sesquiacid) and 48.28 (neutral), will be tabulated as *neutral*, below this figure as *sesquiacid*. Any slag containing more than *53.31CaO%*, the average of 48.28% (neutral) and 58.34% sesquibasic, will be tabulated as *sesquibasic*, below that figure as neutral. Any slag containing more than *61.73CaO*, the average of 58.34 neutral and 65.12 (bibasic), will be tabulated as *bibasic*, below this *sesquibasic*.

Any slag containing more than *69.42%* CaO average of 65.12 (bibasic) and 73.70 (tribasic) will be tabulated as *tribasic*, below this as bibasic.

We give in a special column the amount of lime contained in each type, the figures being followed by capital letters, the first letters of the denomination of each type. Thus: A stands for acid, SA for sesquiacid, N for neutral, SB for sesquibasic, B for bibasic, T for tribasic.

In the next column we have put down the preceding figures, representing the *limit* of lime at which a slag has been classified under the type next in basicity. This was done in case of a possible approximation to one type, leaving in doubt the character of the slag; but, as it will be noticed, it was not necessary in any case. Another column contains the character of the slag determined as explained. The next gives the character of the pig iron accompanying each slag, and the last contains such observations as may explain certain anomalies observed in the type in connection with the grade of iron, or such other special data regarding certain slags which make them rather abnormal. For details we refer to notes, pages 69 to 71, and to the Table VI., which gives the composition in full.

TABLE VII.

Nos. of Slags.	Equivalent of Lime in slag.	Lime in nearest type.	Limit of lime deciding type.	Character of Slags.	Character of Pig Iron Run.	Observations.
1	55.30	58.34 S. B.	53.31	Sesquibasic.	Gray, No. 3.	
2	57.37	58.34 S. B.	"	Sesquibasic.	White.	
3	65.00	65.12 B.	61.73	Bibasic.	Gray, No. 2.	
4	57.50	58.34 S. B.	53.31	Sesquibasic.	Gray.	10.99 FeO and 5.80 MnO in Slag.
5	32.00	31.81 A.	35.08	Acid.	Gray.	
6	48.00	48.28 N.	43.31	Neutral.	Mottled.	
7	53.00	58.34 S. B.	53.31	Sesquibasic.	Gray.	Very hot blast. MnO 25.84.
8	48.30	48.28 N.	43.31	Neutral.	White.	MnO 33.96. Spiegeleisen.
9	60.00	58.34 S. B.	53.31	Sesquibasic.	White.	Cold blast.
10	62.00	" S. B.	"	Sesquibasic.	White.	?
11	56.00	" S. B.	"	Sesquibasic.	Gray.	Puddle cinders in the charges.
12	59.00	" S. B.	"	Sesquibasic.	Gray.	" " " "
13	63.30	65.12 B.	61.73	Bibasic.	Gray, No. 1.	
14	64.00	" B.	"	Bibasic.	Gray, No. 2.	
15	61.80	" B.	"	Bibasic.	Gray, No. 2.	
16	61.00	" B.	"	Bibasic.	Gray, No. 2.	
17	66.30	" B.	"	Bibasic.	Gray.	
18	54.40	58.34 S. B.	53.31	Sesquibasic.	Light gray. Mottled.	MnO=6.37; FeO=4.39. Cold blast.
19	72.50	73.70 T.	69.42	Tribasic.	Gray, No. 1.	MnO; 8.76.
20	65.20	65.12 B.	61.73	Bibasic.	Gray.	
21	62.20	" B.	"	Bibasic.	Gray and mottled.	
22	61.90	" B.	"	Bibasic.	Mottled and gray.	
23	65.10	" B.	"	Bibasic.	Gray.	
24	58.80	58.34 S. B.	53.31	Sesquibasic.	Gray forge. M.	
25	61.30	" S. B.	"	Sesquibasic.	Gray forge.	
26	63.50	65.12 B.	61.73	Bibasic.	Gray.	
27	53.30	58.34 S. B.	53.31	Sesquibasic.	Gray.	MnO 25.84%.
28	53.60	" S. B.	"	Sesquibasic.	White.	MnO 33.96.
29	46.40	48.28 N.	43.31	Neutral.	White.	MnO 26.20.
30	47.70	" N.	"	Neutral.	White.	MnO 5.46%; FeO 6.80.
31	46.50	" N.	"	Neutral.	White.	MnO 33.40.
32	58.37	58.34 S. B.	53.31	Sesquibasic.	White.	MnO 29.20; FeO 21.50.
33	67.00	65.12 B.	61.73	Bibasic.	Gray, No. 1.	
34	69.50	73.72 T. B.	69.42	Tribasic.	Scotch gray, No. 1.	
35	66.50	65.12 B.	61.73	Bibasic.	Scotch gray, No. 2.	
36	66.40	" B.	"	Bibasic.	Gray, No. 1.	Graphitic Iron.
37	66.40	" B.	"	Bibasic.	Gray, No. 1 and No. 2x	
38	60.00	58.34 S. B.	53.31	Sesquibasic.	White and mottled.	
39	63.07	65.12 B.	61.73	Bibasic.	Gray, Nos. 1 and 2.	¼ Puddled cinder containing 9.47 SiO_2.
40	58.80	58.34 S. B.	53.31	Sesquibasic.	White.	
41	63.16	65.12 B.	61.73	Bibasic.	White.	⅛ Staten Island Hematite. Chromium in iron making it white.
42	65.00	" B.	"	Bibasic.	White.	⅛ Staten Island Hematite. 1.25 Chrom. in iron making it white.
43	62.00	" B.	"	Bibasic.	Gray.	
44	60.00	58.34 S. B.	53.31	Sesquibasic.	White.	
45	53.30	" S. B.	"	Sesquibasic.	Gray forge.	45% Silicates of iron Hornblende and Mica in ore not reduced and increasing unduly SiO_2.
46	65.00	65.12 B.	61.73	Bibasic.	White.	½ Staten Island Hematite. Chromium in iron.
47	59.70	58.34 S. B.	53.31	Sesquibasic.	White.	
48	57.70	" S. B.	"	Sesquibasic.	White.	
49	58.00	" S. B.	"	Sesquibasic.	White.	
50	56.40	" S. B.	"	Sesquibasic.	White.	
51	60.40	" S. B.	"	Sesquibasic.	Gray, No. 2.	
52	56.10	" S. B.	"	Sesquibasic.	White and mottled.	
53	61.80	65.12 B.	61.73	Bibasic.	Gray.	
54	58.70	58.34 S. B.	53.31	Sesquibasic.	Light gray forge.	
55	56.20	" S. B.	"	Sesquibasic.	Mottled and white.	
56	56.20	" S. B.	"	Sesquibasic.	Mottled.	
57	60.20	" S. B.	"	Sesquibasic.	Mottled.	
58	64.60	65.12 B.	61.73	Bibasic.	Gray, No. 2 and No. 3.	
59	63.00	" B.	"	Bibasic.	Gray.	
60	64.10	" B.	"	Bibasic.	Gray, No. 2xx.	
61	62.35	" B.	"	Bibasic.	Gray, No. 2.	
62	57.90	58.34 S. B.	53.31	Sesquibasic.	Gray.	
63	62.30	65.12 B.	61.73	Bibasic.	Gray, No. 3.	
64	63.50	" B.	"	Bibasic.	Gray, No. 2.	
65	61.80	" B.	"	Bibasic.	Gray, No. 3.	
66	59.20	58.34 S. B.	53.31	Sesquibasic.	No. 3 and Mottled.	
67	58.50	" S. B.	"	Sesquibasic.	Mottled.	
68	60.00	" S. B.	"	Sesquibasic.	No. 3, Gray.	
69	61.80	65.12 B.	61.73	Bibasic.	No. 3, Gray dark.	
70	66.50	" B.	"	Bibasic.	Gray. No. 1.	

Referring to the data contained in the preceding table we see that:

When the slags were "*neutral*," which happened five times, the iron was four times white and once mottled.

When they were "*sesquibasic*," which happened 32 times, the iron was twelve times white; three times white and mottled; four times mottled; twice light gray and mottled, and eleven times gray; the shades of gray being mostly light.

When they were "*bibasic*," which happened 30 times, the iron was three times white; twice gray and mottled gray, and 25 times gray, graphitic No. 1, No. 2^{xx}, No. 2^{x} and No. 2, the darker shades corresponding most generally to slags reaching very near the typical bibasic slag or even going beyond it in quantity of lime. *The three cases* when the iron was "white" it was due invariably to the presence of chromium in the pig; chromium making the pig iron white and hard when present in certain quantities; the conditions of the furnace were not normal so far as the study of types of slags is concerned.

When they were "*tribasic*," which happened twice, the iron was No. 1 graphitic iron.

When they were "*acid*," which happened once, the iron was gray.

We are justified in concluding at least from the examples quoted, that, with a neutral slag the iron can be expected to be normally white, exceptionally mottled.

With a slag approaching a sesquibasic slag, according to the conditions of the furnace, height, temperature and pressure of blast, the iron can be expected to affect the lightest grades of gray or to be mottled, being white only in special conditions, and a darker gray if the composition of the slag is decidedly sesquibasic. Irons run with such slags are very advantageous as forge irons. The pig contains a greater percentage of iron and less silicon and carbon than grayer pigs, conditions very favorable in the puddling process, which is intended to eliminate all substances foreign to the iron.

With a bibasic slag, in normal conditions of ores and charges, we can expect invariably a gray pig from the darkest shades to

No. 2. No. 1, No. 2^{xx} and kish cinders, if the composition in lime reaches over the type of bibasic No. 2^{x} and No. 2, if not quite up to the percentage of lime of the latter, as the case may be.

With a tribasic slag the iron will invariably be a No. 1 iron, Scotch gray (judging from the limited number of examples of such slags, which are not very economical).

An acid slag, as could be expected from diminished fusibility when the proportion of silica goes above a certain limit, corresponds to gray iron.

The higher grades of iron contain the most silicas and carbon (total carbon), corresponding therefore to higher temperatures in a furnace, a condition necessary to insure the reduction of the silica and the passage of silica into the pig, as well as the solution of the carbon in the molten iron ; they are accompanied by the more basic slags. Blast furnace practice corroborates then completely the direct experiments on the fusibility of silicates which showed that the more basic they are the less their fusibility, and that, beyond a certain limit of acid, the silicates become again more refractory.

If objections are made to the denomination "Basic," "Bibasic," "Neutral," slags used in this discussion, we can say: Putting aside all considerations as to the molecular constitution of silicates and taking only as a guide *the oxygen ratio, an element of comparison which the analysis furnishes in all cases.*

The silicates in which the ratio of oxygen of SiO_2 to oxygen of the bases is comprised between 4 : 3 (Sesquibasic.) and 4 : 4 (1 : 1) (Bibasic.) accompany most invariably the higher grades of iron ; when this ratio falls between 4 : 2 (neutral 2 : 1) and 4 : 3 (sesquibasic), mottled iron and lighter grades of gray may be expected, darker as the ratio approaches 4 : 3.

At 4 : 2 (2 : 1), white iron and occasionally mottled iron can be depended upon. When this ratio reaches 1 : 4 (acid), the fusibility appears to diminish again, and as a consequence, the darkest grades are obtained.

At 4 : 6 (2 : 3) (tribasic) graphitic iron and kish cinder are the

rule. If these deductions are correct, and the more numerous the observations the better their truth could be ascertained, their importance is not to be overlooked. The failure to obtain a certain grade of iron with a given slag within certain limits would then be a warning to an intelligent iron master to look in his ores or other materials charged in the furnace, for a disturbing element or for abnormal conditions of temperature, volume and pressure of blast. It would call for a thorough chemical analysis. The same ores frequently change in composition. When silica is present in a combined state in an iron ore, as hornblende or iron mica, these silicates of iron may melt before being reduced, especially in a low furnace, and pass out in the slag *as such*, and unreduced completely changing *its character* as calculated from a "general analysis," or "expected" from a previous practice with the same ores. Such a circumstance did present itself in one of the slags quoted, No. 45. It showed at the analysis 50.10 silica and 4.88 FeO, corresponding, transformed into lime, to a slag containing 53.20 CaO, just about the limit, 53.31, to be called a sesquibasic slag (58.34); it was tabulated so, but, strictly speaking, it was nearer a neutral slag, 48.28. With such a slag an iron of lighter gray than gray forge iron was to be expected. If a darker one was obtained, it was certainly due to the fact that, omitting the *silicate of iron* melted without reduction in a low furnace, and existing simply as an *inert matter* in the liquid slag, the slag had a different saturation for silica than the apparent one. A more complete and thorough examination of the slags quoted would disclose for several of them other anomalies, more or less important, but it would carry us too far. We have intended to show, only in a general manner, that the relation between the chemical character of a slag and grade of iron is much closer than, we believe, it is generally admitted to be, leaving far more complete and numerous observations to determine the question, not forgetting the wise maxims of Sir Lowthian Bell and his reserve: "If it is proper to give an opinion on a subject which one has not *thoroughly* experimented."

The following Tables VIII. and IX. recapitulate practically the results of this examination. No formulæ or symbols are used in

it; the bases being called by the names they are generally known by. It is, so to speak, a practical table allowing any one not familiar with technical chemistry to transform a slag of any composition into lime and also to find the oxygen ratio if desired. Comparing the results with those tabulated, the character of the slag can be ascertained and permit its fusibility and the iron "likely" to be expected in normal conditions of furnace, as well as its relation with another one. The Table IX. of equivalence includes all the bases likely to be met with in slags, some as constant elements, others as occasional ones in certain localities. Table VIII. giving also the saturation of lime for silica, or inversely, for different types of slags of different fusibility these figures can readily be used, as explained previously, for the calculation, *a priori*, of a slag from certain charges in ores, stone and coal of which the analyses may be given:

TABLE VIII.—TYPES OF SLAGS (*Resumé*).

Chem. Denomination: *Acid.* Disilicates.	Chem. Denomination. *Sesquiacid.* Trisilicates.	Chem. Denomination: *Neutral.* Metasilic Monosilicates.	Chem. Denomination: *Sesquibasic.* Disilicates.	Chem. Denomination: *Bibasic.* Orthosilic Monosilicates.	Chem. Denomination: *Tribasic.* Parasilicic Monosilicates.
Oxygen Ratio: O of Silica: O of Bases 4 : 1	Oxygen Ratio: O of Silica: O of bases 3 : 1	Oxygen Ratio: O of Silica: O of bases 2 : 1	Oxygen Ratio: O of Silica: O of bases 4 : 3	Oxygen Ratio: O of Silica: O of bases 1 : 1	Oxygen Ratio: O of Silica: O of bases 2 : 3
Composition: Silica .....68.19 Lime.....31.81	Composition: Silica.....61.65 Lime..... ..38.35	Composition: Silica.....51.72 Lime..... .....48.28	Composition: Silica.....41.66 Lime..... ..58.34	Composition: Silica.....34.88 Lime..... ...65.12	Composition: Silica.....26.30 Lime.....73.70
Saturation: 1 Lime satur..2.143 Silica 1 Silica saturates.... 0.466 Lime	Saturation: 1 Lime... ..1.607 Silica 1 Silica.....0.622 Lime	Saturation: 1 Lime.....1.071 Silica 1 Silica.....0.932 Lime	Saturation: 1 Lime.....0.714 Silica 1 Silica.....1.400 Lime	Saturation: 1 Lime....0.538 Silica 1 Silica.....1.858 Lime	Saturation: 1 Lime....0.357 Silica 1 Silica....2.829 Lime
Fusibility: "Fusible."	Fusibility: "Moderately Fusible."	Fusibility: "Very fusible."	Fusibility: "Very fusible," but less than preceding one.	Fusibility: "Fusible."	Fusibility: "Fusible," but less than preceding one.
Grade of iron likely to accompany such slag: Gray No. 2.	Grade of iron likely to accompany such slag: Gray, lighter.	Grade of iron likely to accompany such slag: White.	Grade of iron likely to accompany such slag: Mottled and Lighter Grays.	Grade of iron likely to accompany such slag: Gray No. 2, No. 2x, No. 2xx, and No. 1 occasionally.	Grade of iron likely to accompany such slag: Gray No. 1. Kish Cinder.

TABLE IX.

Bases likely to be found in slags.

Equivalence in Lime.		Oxygen in 1 lb. of Base.
1 lb. Alumina	= 1.631 Lime	0.466
1 lb. Magnesia	= 1.400 "	0.400
1 lb. Potash	= 0.594 "	0.170
1 lb. Soda	= 0.903 "	0.258
1 lb. Iron Oxide (FeO)	= 0.780 "	0.222
1 lb. Manganese Oxide (MnO)	= 0.780	0.225
1 lb. Baryta	= 0.365	0.104
1 lb. Copper Oxide (CuO)	= 0.704	0.201
1 lb. Lithia	= 1.866	0.550
1 lb. Nickel Oxide (NiO)	= 0.747	0.213
1 lb. Iron Sesquioxide (Fe_2O_3)	= 1.050	0.300
1 lb. Chromium Sesquioxide (Cr_2O_3)	= 1.100	0.314
Iron and Chromium Sesquioxide, (Ferric and Chromic oxide,) to be treated as Alumina.		O of Silica: 0.533

SYNTHESES IN THE SUGAR GROUP.

By Emil Fischer.*

Translated by L. H. Friedburg, Ph. D.

Until quite recently the sugars of the formula, $C_6H_{12}O_6$, were considered as the simplest members of the group. As long as the synthesis had not been applied products of animal and vegetable life were the only sources for the small number of sugars. In 1886 we knew four sugars of the formula $C_6H_{12}O_6$, viz.:

Grape sugar, or glucose.
Fruit sugar, or laevulose.
Galactose.
Sorbinose.

Closely connected with these is arabinose which Scheibler, its discoverer, held to be an isomere of glucose, while Kiliani[1] in 1887 characterized it as a compound, $C_5H_{10}O_5$. A few other substances had in former times been erroneously incorporated into the sugar series. Of these inosite and dambose, which are identical, have been recognised by Maquenne[2] as derivatives of hexamethylene, while others, such as phlorose[3], corcose[3] and cerebrose[4] are no longer considered as being chemical individuals.

Of the four remaining sugars the rare sorbinose has been but sparingly examined. According to the latest communications of Kiliani and Scheibler[5] it seems to have the same constitution as laevulose.

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* *Ber. d. Chem. Ges.*; **23**, *2114* (*Abstract.*)
[1] *Ber. d. Chem. Ges.*, **20**, *339*.
[2] *Compt. rend.*, **104**.
[3] *Ber. d. Chem. Ges.*, **21**, *988*.
[4] *Thierfelder, Zeitschr. für physiol. Chem.*, **14**, *209*.
[5] *Ber. d. Chem. Ges.*, **21**, *3276*.

On the other hand the structure of the three other important sugars was essentially known before my own researches began.

The formulæ now in use for glucose and galactose:

CH_2 (OH). CH (OH). CH (OH). CH (OH). CH (OH). COH;

and for laevulose:

CH_2 (OH). CH (OH). CH (OH). CH (OH). CO. CH_2 (OH) are derived from the following facts:

Sodium amalgam changes glucose and laevulose into mannite; while galactose under the same conditions furnishes dulcite. But mannite and dulcite are to be considered as the hexatomic alcohols of normal hexane, because they are able to take up six acetyl groups and to furnish normal hexyl iodide with hydriodic acid. Furthermore glucose and galactose when subjected to moderate oxidation by means of chlorine or bromine water yield the monobasic gluconic and galactonic acids and, on continued oxidation, the bibasic saccharic and mucic acids. They consequently contain the aldehydic group.

Zincke[6] and V. Meyer[7] objected to this conclusion, upon the basis that ketones also with the group CO. CH_2 (OH), as for instance acetylcarbinol, may be transformed into oxyacids. This objection is not justified, because the formation of gluconic and galactonic acids takes place in acid solution, while the transition of acetylcarbinol into lactic acid has been effected only by alkaline oxidizers. In this latter case the carbinol may at first be transformed into the aldehyde, methylglyoxal, which then, under the influence of alkali must at once change to lactic acid.

Unlike the two aldehydes, laevulose is but very slowly attacked by cold bromine water and under the influence of more severe oxidizers it decomposes into products less rich in carbon[8].

All three sugars combine like the ordinary aldehydes or ketones with hydrocyanic acid. By saponification of the cyanhydrines formed, three different acids, $C_7H_{14}O_8$, are produced which are changed into heptylic acids when boiled with hydriodic acid.

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[6] *Ber. d. Chem. Ges.*, **23**, *636* and *Ann. Chem.* (*Liebig*), **216**, *318*.

[7] *Ber. d. Chem. Ges.*, **23**, *2344*.

[8] *Kiliani, Ann. Chem.* (*Liebig*), **205** *175*.

Under these conditions glucose and galactose furnish normal heptylic acid, while laevulose is transformed into methylbutylacetic acid.

This method devised by Kiliani[9], I consider to mark the greatest progress in the study of the sugar group during several decades. By its aid the old formula for glucose was confirmed and the ketonic formula given above for laevulose put beyond ambiguity. In the same manner Kiliani found the structure of arabinose[10] to be $CH_2(OH).CH(OH).CH(OH).CH(OH).COH$.

The addition of hydrocyanic acid implies the first successful step toward synthesis of compounds richer in carbon out of natural sugars.

Another support for the formula of glucose and galactose has been found recently in the observation that they form hydrazones[11] and oximes[12] just as the simple aldehydes do.

The only objection against the aldehyde formula which is maintained up to date, concerns the indifference of sugars towards fuchsine-sulphurous acid[13]. But this objection loses its importance if we consider that heretofore no simple oxyaldehyde of the fatty series has been tested by this reagent. For the time being it seems therefore not justifiable to replace the aldehyde formula by any other, especially as it explains all simple metamorphoses of the two compounds.

Thus the formulæ for the three kinds of sugar are derived from observations seemingly ample enough to serve as a basis for syntheses. But it was different in regard to the methods which were in use for the recognition and isolation of these compounds. Whosoever has tried to obtain glucose or laevulose in a pure state, from salt solutions only, by the methods formerly in use, will agree that it is quite impossible in that way to isolate such an artificial product from a mixture with other organic compounds and to characterize it as a chemical individual.

This want of suitable methods I experienced vividly myself

[9] *Ber. d. Chem. Ges.*, **18**, *3066*; **19**, *221, 767, 1128*.
[10] *Ber. d. Chem. Ges.*, **20**, *339*.
[11] *Fischer, Ber. d. Chem. Ges.*, **20**, *824*.
[12] *Rischbieth, Ber. d. Chem. Ges.*, **20**, *2673*.
[13] *V. Meyer, Ber. d. Chem. Ges.*, **13**, *2343*.

when seven years ago I attempted *for the first time the synthesis of a sugar* from the bromine compound of acroleine. At that time I obtained by decomposition of the bromide with baryta water a syrup which showed the ordinary sugar reactions. But all endeavors to obtain a pure preparation from the raw product were without sucess. Only four years later this was obtained after a useful agent for this purpose had been found in phenylhydrazin[14].

The reaction between this base and sugars is easily shown as follows: Adding to a warm aqueous ten per cent. solution of glucose, a solution of phenylhydrazin in dilute acetic acid, the mixture at once assumes a yellow color. Heating on the water bath leads in ten or fifteen minutes to a deposit of fine yellow needles, which finally fill the entire liquid like a pulp. These needless have the composition $C_{18}H_{22}N_4O_4$, and are called glucosazone. They are formed by combination of one molecule of sugar and two of phenylhydrazin.

But the formation of this substance takes place in two phases.[15] At first, the sugar combines, like common aldehydes, with one molecule of the base to an hydrazone of the formula: CH_2 (OH). [CH (OH)]$_3$ *CH (OH). CH : N. NH. C_6H_5.

This compound is easily soluble in water and consequently passes unnoticed in the experiment. On heating this hydrazone with an excess of hydrazin, it suffers a peculiar oxidation. The alcoholic group marked * in the above formula, is transitorily changed into a carbonyl group which latter then fixes in known manner a second molecule of phenylhydrazin. Thus the glucosazone results, the structure of which is given by the formula:

$$\begin{array}{l} CH_2\,(OH).\ [CH\,(OH)\,]_3.\ C - CH \\ \qquad\qquad\qquad\qquad\quad \| \qquad \| \\ \qquad\qquad C_6H_5.\ NH.\quad N \quad N.\ NH.\ C_6H_5 \end{array}$$

We are forced to look at the reaction in this way by the behavior of laevulose, which permits the entrance of the hydrazin groups in an inverted sequence. In this case also the first step

[14] *Ber.d. Chem. Ges.*, **17**, *579*.
[15] *Ber.d. Chem. Ges.*, **20**, *822*.

consists in the formation of an hydrazone easily soluble in water and non-crystallizable.

$$CH_2(OH)\,[CH\,(OH)]_3.\,C - CH_2\,(OH)$$
$$\quad\quad\quad

The osazones, which are almost insoluble in water, have proved to be still more valuable for the developement of work in the sugar group. They crystallize with comparative ease and precipitate even from most dilute solutions. In addition, they differ in solubility, melting point and in optical behavior, and they are now consequently used for recognizing natural sugars.

The derivatives of these latter, as well as the important marks of difference are put down in the following table:

Glucosazone, $C_{18}H_{22}N_4O_4$. Is formed from glucose, laevulose, mannose, glucosamine and isoglucosamine. Almost insoluble in water, difficultly soluble in hot alcohol. Melting point near 205° C. The solution in glacial acetic acid turns the plane of polarization to the left.

Galactosazone, $C_{18}H_{22}N_4O_4$. From galactose. Almost insoluble in water, a little more soluble in alcohol than the preceding. Melting point near 193° C. No noticeable action on polarized light when dissolved in glacial acetic acid.

Sorbinosazone, $C_{18}H_{22}N_4O_4$. From sorbinose. Almost insoluble in water, easily soluble in hot alcohol. Melting point 164° C.

Lactosazone, $C_{24}H_{32}N_4O_9$. From lactose. Soluble in 80 to 90 parts of hot water. Melting point near 200° C. Dilute sulphuric acid changes it into its anhydride $C_{24}H_{30}N_4O_8$, which is almost insoluble in water.

Maltosazone, $C_{24}H_{32}N_4O_9$. From maltose. Soluble in about 75 parts of hot water. Melting point near 206° C. Does not furnish an anhydride.

Arabinosazone, $C_{17}H_{20}N_4O_3$. From arabinose. Sparely soluble in hot water, easily soluble in hot alcohol. Melting points near 160° C. Its alcoholic solution shows no action upon the polarized light.

Xylosazone, $C_{17}H_{20}N_4O_3$. From xylose. Deceptively similar to arabinosazone, but, in alcoholic solution strongly turns polarized light to the left.

Rhamnosazone, $C_{18}H_{32}N_4O_3$. From rhamnose (isodulcite). Almost insoluble in water, easily soluble in hot alcohol. Melting point near 180° C.

As before stated, the osazones are formed by a process of oxidation. The reconversion into sugars is consequently much more difficult than with the hydrazones. But for the investigation of synthetical sugars which could only be isolated in the form of osazones, a way to effect this conversion had inevitably to be obtained. After many vain experiments I have found a way in the following two reactions :

Zinc dust and acetic acid reduce the osazones to nitrogenized, basic products. The glucosazone thus forms a compound, $C_6H_{13}NO_5$, which is isomeric with the glucosamine discovered by Ledderhose and which consequently was called isoglucosamine.[17] It forms a beautifully crystallizing acetate and has the structural formula :

$$CH_2(OH).\ CH(OH).\ CH(OH).\ CH(OH).\ CO.\ CH_2.\ NH_2.$$

Its formation from the osazone is a very remarkable process. One hydrazine group is split off entirely; in the other one the nitrogen chain is broken by the nascent hydrogen, aniline being formed. The other nitrogen atom remains united with carbon of the sugar molecule, in form of an amido group. If the base is treated with nitrous acid in the cold, it loses its amido group and is easily transformed into fruit sugar.[18]

But this treatment which furnishes such good results for the glucosazone, is not applicable in other cases, simply because the corresponding bases do not crystallize and cannot therefore be isolated from the mixture of the reaction.

Far more serviceable is the second method. Fuming hydrochloric acid splits the osazones of the sugar group into phenylhydrazine and the so called osones.[19] Considering the glucosazone the process takes place according to the following equation :

$$\underset{\text{Glucosazone.}}{C_6H_{10}O_4(N_2H.C_6H_5)_2} + 2H_2O \quad \underset{\text{Glucosone.}}{C_6H_{10}O_6} + 2C_6H_5.\ N_2H_3.$$

But the practical performance of this reaction requires very close attention. The following experiment shows the condi-

[17] *Ber. d. Chem. Ges.*, **19**, *1920*.
[18] *Ber. d. Chem. Ges.*, **20**, *2569*.
[19] *Ber. d. Chem. Ges.*, **22**, *87*.

tions for a successful operation. To finely powdered glucosazone the tenfold quantity of fuming HCl is added. It turns dark red, and a portion goes into solution with the same tint. It is thus transformed into its hydrochloride, which, however, is decomposed by water. If the mixture is rapidly heated to 40° C. and vigorously shaken a clear solution is obtained. This is kept for but one minute at 40° C. and then cooled down to 25° C. Now an ample crystallization of phenylhydrazine hydrochloride sets in which indicates the splitting of the osazone. At the same time the dark red tint of the liquid turns to a dark brown. In ten minutes the reaction is finished. The filtered liquid is freed from HCl and the glucosone is precipitated as an insoluble lead compound. It has not, so far, been made to crystallize, and, consequently, could not be analyzed, but its reactions, which correspond absolutely to those of glyoxal and with 1, 2–diketones, do not leave any doubt, that the compound is the aldehyde of fruit sugar and possesses the formula :

$$CH_2(OH).\ CH(OH).\ CH(OH).\ CH(OH).\ CO.\ COH.$$

The behavior towards phenylhydrazine is particularly characteristic. The cold aqueous solution upon addition of phenylhydrazine acetate becomes rapidly turbid, and in five to ten minutes a dense precipitate of glucosazone is formed.

The glucosone combines also with aromatic orthodiamines and forms well-crystallizing chinoxaline derivatives. Finally its transformation by means of nascent hydrogen is particularly interesting, since heating with zinc dust and acetic acid changes it entirely into fruit sugar.

This method thus leads from grape sugar by way of the osazone and osone to fruit sugar and it is to be expected that in this manner most of the still unknown ketone sugars will be prepared from all aldehyde sugars. If we want to return from the ketone sugars to the aldehyde sugars we have to go by way of the alcohol. Considering the last example, the transformation would be as follows : Fruit sugar is easily reduced to mannite by means of sodium amalgam. Careful oxidation with nitric acid forms out of this its aldehyde, the mannose, and further, from this, as I shall show, grape sugar.

In studying the sugars the osazones are capable of application to other purposes.

The formulæ $C_6H_{12}O_6$; $C_5H_{10}O_5$; $C_7H_{14}O_7$, etc., showing the same percentage composition, the analysis alone of these sugars will never allow to decide in regard to the number of carbon atoms; we are therefore forced to analyze a derivative. For this purpose the osazones are best fitted since, as a rule, they may be obtained in a very pure state. They have been utilized so far for the determination of the empirical formulæ of arabinose [20], sorbine[21] and xylose [22].

In still other cases the osazones offer a new means of determining the constitution of a sugar. In former times rhamnose (isodulcite) was considered to be a hexatomic alcohol and an analogue of mannite, although its reducing action upon alkaline copper sol. was known. But the use of the hydrazin test showed, in furnishing[23] an osazone, $C_6H_{10}O_3\ (N_2H.\ C_6H_5)_2$, that the anhydrous rhamnose is a sugar of the formula $C_6\ H_{12}\ O_5$, for which later on the structural formula was found[24] to be CH_3. CH(OH). CH (OH). CH(OH). CH(OH). COH.

Another example is offered by milk sugar, which, as we know, is an anhydride of equal molecules of glucose and galactose. Its faculty of forming an osazone proves that it still contains one group—CH(OH). COH. Since, furthermore, the osone which is formed from the osazone decomposes into galactose and glucosone when boiled with dilute acids, it follows that we find in sugar of milk the unchanged aldehydic group of the glucose molecule.[25]

This conclusion, which has been corroborated by the preparation of lactobionic acid[26] and by the hydrolysis of this latter, has led to a new conception of the constitution of milk sugar and of the closely related maltose.

Finally the hydrazones and osazones proved to be particularly valuable for the discovery of new sugars and of substances similar to sugars. These latter are obtained in a comparatively easy manner by moderate oxidation by polyatomic alcohols. As far as I know, it was Carlet[27] who made the first observation of this kind.

[20] *Kiliani, Ber. d. Chem. Ges.*, **20**, *345*.
[21] *E. Fischer, Ber. d. Chem. Ges.*, **20**, *827*.
[22] *Tollens und Wheeler, Ann. Chem. (Liebig)*, **254**, *315*.
[23] *Fischer und Tafel, Ber. d. Chem. Ges.*, **20**, *1091*.
[24] *Fischer und Tafel, Ber. d. Chem. Ges.*, **21**, *2173*; see also *Maquenne, Compt. Rend.*, **109**, *603*.
[25] *Fischer, Ber. d. Chem. Ges.*, **21**, *2633*.
[26] *Fischer und Meyer, Ber. d. Chem. Ges.*, **22**, *361*.
[27] *Jahresbericht für Chemie (1860)*, *250*.

(To be continued.)

ABSTRACTS.

GENERAL CHEMISTRY.

Combustion under High Pressure. W. HEMPEL.

It is a known fact, that the combustion of sulphur furnishes noticeable quantities of sulphuric anhydride along with sulphur dioxide. Also that hydrogen, illuminating gas or carbon when burned, allows the formation of nitrous acid easily to be shown. In the present research the attempt was made to study the influence of increased pressure upon these phenomenæ.

The combustions of sulphur was performed in dry oxygen and in iron vessels, for those of nitrogen a drilled piece of cast steel was used, which formed an "autoclave" of 28 c. c. capacity, lined inside with platinum. The inflammation was performed with the aid of a platinum wire, of 0.15 to 0.2 m. m. thickness, which by means of the electric current was momentarily heated to its melting point. For this purpose two insulated pieces of thick platinum wire had been introduced through the head of the autoclave. These acted at the same time as a support for pieces of sulphur or carbon. The air was compressed by a powerful air pump. Oxygen and detonating gas were condensed by the pressure formed by developing these gases in a closed space. Oxygen was developed from a mixture of equal parts of $K\,ClO_3$ and $Mn\,O_2$ in a retort formed from a bent iron tube of thick wall. A small iron digestor served for the preparation of detonating gas in which water, acidulated by H_2SO_4, was decomposed electrolytically. The digestor itself was the cathode, while a piece of platinum sheet, well insulated, led into it. During the performance of the experiments the apparatus was surrounded by a protective screen formed of boxes filled with sand. When very high pressures were used the experiments were performed with the aid of mirrors, so that operations were possible without endangering the experimenter.

This mode of arranging the experiments has the advantage that no combustion takes place during the time of compression; combustion occurs at comparatively low pressures when using a pump. Thus oxygen will set on fire the leather packing at about 40 atm. It is evident that even when using asbestos packing (which Wroblewsky used in his experiments on condensation of gases), the combustion of detonating gas cannot be avoided. The compression of the gases sets free so much heat, that the temperature of combustion is reached at a pressure of several hundred atmospheres. Lead disks which were used for packing will resist a pressure of several thousand atmospheres. The pressures were read by means of manometers furnished by Schaeffer and Budenberg.

The experiments with sulphur show that it is possible to convert half of the amount used directly into sulphuric anhydride. When the digestor was opened fumes appeared as when a bottle of sulphuric anhydride is opened. When water was introduced hissing occurred.

The experiments with a mixture of nitrogen and detonating gas and those with nitrogen and lignite proved that great quantities of nitrogen may be directly united with oxygen under high pressures. (*Ber. d. Chem. Ges.*, **23**, *1455.*) L. H. F.

Formation of Nitrous Acid and Ammonia from Free Nitrogen. O. Loew.

Dried platinum sponge, which will not yield to water even traces of either nitrous acid or ammonia, at once furnishes these two bodies when treated with sodium hydrate solution. If this solution is very dilute $\left(\text{about } \frac{1}{1000}\right)$, nitrous acid reactions are obtained and not those of ammonia. As Nessler's reagent indicates $\frac{1}{10000000}$ of ammonia just as distinctly as the reaction of Griess' does the same amount of nitrous acid, the conclusion is drawn that two processes take place under the simultaneous influence of the sponge and of the sodium hydrate:

1. Nitrogen, condensed in small quantities together with oxy-

gen upon the platinum sponge, is directly oxidized to nitric oxide, and this then further into nitrous acid.

2. Using concentrated sodium hydrate, the nitrogen also *reacts with water*, forming ammonium nitrite. (*Ber. d. Chem. Ges.*, **23**, *1443.*) L. H. F.

Action of the Electric Arc Light upon Gaseous Bodies and its Use for Demonstrations. B. LEPSIUS.

The arc light is used with success in quite a number of experiments instead of the induction spark or the dark discharge. The volumetric relations between CO_2 and CO, of O to CO, of O to CO and CO_2 have so far been studied. (*Ber. d. Chem. Ges.*, **23**, *1418.*) L. H. F.

The Chemical Constitution of Talc. F. W. CLARKE and E. A. SCHNEIDER.

The stability of talc towards hydrochloric acid is shown, as well as its decomposition on heating, setting free silicic acid.

These facts can only be reconciled with a formula indicating a meta-silicate. (*Ber. d. Chem. Ges.*, **23**, *1537.*) L. H. F.

The Constitution of Solutions. FR. RÜDORFF.

It follows from this research on the freezing points of solutions of mixed salts, that salts which are able to form double salts react upon each other when dissolved together, even far from the point of saturation. This is not the case for salts that do not form double salts. (*Ber. d. Chem. Ges.*, **23**, *1846.*) L. H. F.

The Carbohydrates of the Sweet Potatoe (*Batatas edulis*). W. E. STONE.

This research shows that the sweet potatoe does not contain reducing sugar, but cane sugar in quantities of 1½ to 2 per cent. Baking transforms a considerable amount of the starch into a soluble form, at the same time hydrolizing saccharose to glucose. (*Ber. d. Chem. Ges.*, **23**, *1406.*) L. H. F.

A new Crystallizable Carbohydrate. A. VON PLANTA and E. SCHULZE.

The nodose roots of *Stachys tuberifera* furnish a crystallizable carbohydrate of the composition $C_{18}H_{32}O_{16}$, or a multiple of the same. The body crystallizes with $3\,H_2O$. It has received the name stachyose and belongs to the group which Tollens calls crystallizable polysaccharides, embracing: raffinose (melitose), gentianose and lactosin. The stachyose resembles most this last mentioned one. (*Ber. d. Chem. Ges.*, **23**, *1692.*) L. H. F.

On a Second Monobrombenzol. F. FITTICA.

A. Hand has not only disputed the existence of the author's fourth monobromphenol,* but also that of his second monobrombenzol. In rebuttal, Fittica describes the precautions to be taken in the preparation of this second monobrombenzol which boils at 62° C., while the common monobrombenzol has the boiling point 155° C. (*Ber. d. Chem. Ges.*, **23**, *1398.*) L. H. F.

A New Method for the Determination of Free and Combined Carbon in Iron or Steel. OTTO PETTERSSON and A. SMITT.

0.4 to 0.8 grms. of the material, best in the form of filings or as a single thin sheet, is fused with potassium bisulphate. The operation takes from 5 to 12 minutes, or longer when filings are used. The iron is transformed into ferrous sulphate while equivalent quantities of SO_2 are developed. The combined carbon is oxidized to CO_2, the graphite remains in the shape of bright, crystalline leaves. By means of a current of air, free from CO_2, sulphur dioxide and carbon dioxide are expelled and absorbed by a measured quantity of caustic soda and baryta lye; thus barium sulphite and barium carbonate are precipitated. The former is oxidized to sulphate by permanganate in slight excess. The liquid is then acidulated with HNO_3 and the CO_2 determined, using aluminium wire to assist in the development of gas.† The

* New York Acad. Ann., **3**, 67, (1884).

† See Otto Pettersson's method for the determination of CO_2, page 354.

graphitic carbon is retained in the fused mass which is perfectly white and easily soluble in warm HCl. The graphite is collected on a little platinum filter with asbestos, dried, gently heated and weighed. Then the filter, while glowing, is subjected for a few minutes to a current of air charged with nitrous vapors. After thus burning the graphite, the filter is weighed again and is at once ready for new use. The development of this mode of analysis occupied over three years until the desirable exactness of 0.01 to 0.02 pr. ct. was assured. (*Ber. d. Chem. Ges.*, **23**, *1401.*)

L. H. F.

Experiments for Quantitative Determination of Arsenic by Marsh's Test. Behavior of Arsine towards Potassium Hydrate. B. KÜHN and O. SAEGER.

The experiments described tend to show that larger quantities of arsenious acid (0.11 grms. $As_2 O_3$ dissolved in 25 c. c. water to which a few drops of KOH sol. were mixed), hence, if the latter be added in greater concentration to the hydrogen apparatus, the arsenic is transformed within three hours almost quantitatively into $As H_3$ and from this into elementary arsenic.

Attention is drawn to the fact that an error has crept from Dragendorff's[1] "Lehrbuch" into all others. It is said in Dragendorf that arsine is not decomposed by potassium hydrate, while stibine is entirely decomposed by the same. This is not correct. Arsine is decomposed more slowly and not as perfectly, but the introduction of a potassium hydrate tube in medico-legal cases is not permissible. If antimony should be present it must be separated previously and by precipitation. (*Ber. d. Chem. Ges.*, **23**, *1798.*)

L. H. F.

Determination of Nitric Acid, according to Schulze-Tiemann. L. SPIEGEL.

Several years ago, when reporting upon the determination of nitric acid in potable water, the author criticised Schulze-Tiemann's method, claiming that it yielded results with an error

[1] Dragendorf, Die gerichtlich-chemische Ermittlung der Gifte. 2 Auflage, S. 633.

of at least 3 per cent. This determination being performed with the aid of ferrous chloride, and conc. HCl, in a partial vacuum, the error referred to may be avoided by using a current of carbon dioxide, free from air, towards the end of the process. Tiemann in a new edition of his "Water analysis," does not accept this modification of the process. The author maintains the value of his proposal; he works from the beginning in a current of CO_2, and describes a simple apparatus which serves for this determination. (*Ber. d. Chem. Ges.*, **23**, *1361.*) L. H. F.

Method for the Determination of Carbon Dioxide. OTTO PETTERSSON.

A general mode of determining CO_2 quantitatively in all solid and liquid substances. The method is particularly useful for estimating CO_2 in a state of solution or of partial combination *e. g.*, in natural well or sea water. For details of this method see the original article which describes the apparatus used and gives a diagram. A peculiarity of this determination is that a small piece of iron or aluminium wire is used as a hydrogen developer in the vacuum apparatus in which carbon dioxide is set free. This simultaneous generation of minute quantities of hydrogen is claimed as essential, partly in order to drive out all of the CO_2, partly to prevent bumping. The gases developed are measured while moist in a burette over mercury. Afterwards the CO_2 is absorbed in the ordinary manner by KOH solution in an Orsat tube.

This apparatus has lately been of great service in the analyses of sea water in hydrographic researches in the Skagerack and Kattegatt. The CO_2 was thus determined in more than 110 samples taken from different depths. Franz Müller, in Bonn, makes the apparatus in a most careful manner. (*Ber. d. Chem. Ges.*, **23**, *1402.*) L. H. F.

Abstracts of American Patents Relating to Chemistry.

(From the U. S. Patent Office Gazette.)

(Issued July 15th, 1890.)

432,058.—Vegetable black. E. A. de Lisle.

Contains as its essential characteristic material the calcined residuum of cinchona bark, from which the genuine has been primarily extracted.

432,060.—Composition for preserving eggs. Silas C. Matteson.

Consists of a mixture of ground silica, alumina, peat, ash and clay.

432,091.—Phosphatic fertilizer. J. D. Simmons.

Consists of wood ashes, phosphate of lime, muriate of potash, pulverized sulphur, and nitrate of soda.

432,118.—Wood filler. B. J. Couhig.

Consists of molasses, water, starch, pulverized gypsum, glue and alcohol.

432,151.—Transparent water color paint. R. T. Swenning.

Consists of an aniline dye, water, gum arabic, gelatin, white sugar and alcohol.

432,190.—Apparatus for making vinegar. E. E. Murphy, and W. Berkel.

432,198.—Process of purifying crude alcohol. G. Guignard.

The process of separating the aldehydes or like products from alcohols in general, and the alcohols of the distillery in particular, through the formation of sulphite compounds of the aldehydes or like products by treating the crude or impure alcohol with alkaline bisulphite or alkaline sulphite and bisulphite to form said sulphite compounds, and separating such compounds and the alcohol from each other.

432,240.—Paint compound. A. A. Jackson.

A water and fire proof paint, consisting of coal tar, asphaltum varnish, cane syrup, spirits of turpentine, red mineral, yellow ocher, whiting, water, soda, salt, and alchocol.

432,251.—Refining cocoanut oil. A. Smith.

Cocoanut oil is deodorized by boiling with a sulphide, washing, boiling again with a bisulphite and washing.

432,270.—Carburetor. G. Hargreaves, E. W. Porter, and J. P. Scranton.

432,280.—Metallurgical furnace. R. F. Nenninger.

432,281.—Apparatus for producing highly heated gas. R. F. Nenninger.

432,313.—Lubricant. R. Hutchison.

Composed of lime combined with margaric, stearic or oleic acid, or any suitable mixture of such acids and mineral or hydrocarbon oil, there being an excess of the acid sufficient to make the mineral or hydrocarbon oil combine with the lime compound.

432,336.—Explosive compound. S. D. Smoliauinoff.

Consists of nitroglycerin, an alcohol, and an absorbent.

432,383.—Process of reducing iron ore. C. J. Eames.

432,437.—Detergent. P. K. Post, Jr.

Consists of borax, saturated with ammonia, in the form of a paste or semi-solid.

432,497.—Welding compound. H. B. Straut and C. B. Shute.

Consists of borax, prussiate of potash ammonium chloride, water and chalk.

Issued July 22d, 1890.

432,546.—Filter. T. A. Myers.

432,604.—Apparatus for producing bisulphites. C. Cornwell.

432,692.—Apparatus for producing bisulphite solutions. T. P. Burgess.

432,698.—Process of manufacturing alloys of metal of the aluminium group. G. A. Taurie.

The process consists in exposing an intimate mixture of the oxide of the group metal, carbon, and sulphuric acid to an intense heat, mixing therewith filings of the alloying metal, and exposing the mixture to a white heat.

432,718.—Apparatus for producing gaseous fuel. J. M. Ayer.

432,777.—Fire extinguishing compound. R. T. Van Valkenburg.

Consists of sulphuric acid, a sulphite and a carbonate.

432,784.—Manufacture of white lead. J. A. Boand.

The process consists in constantly stirring and agitating a mass of lead oxide in a closed vessel, passing a stream of carbon dioxide into the mass, and simultaneously passing steam laden with vapor of acetic acid into the mass.

432,808.—Process of extracting oil from fish. P. C. Vogellus.

432,815.—Process of obtaining oxygen from air. A. Brin.

Barium oxide is heated, admitting air thereto until peroxidation takes place, then shutting off the air supply and deoxidizing the barium by reducing the pressure without changing the temperature of the heating chamber.

432,853.—Leather blacking. J. J. Baulch, F. C. Steele, W. J. Lees, and J. F. Evans.

A waterproof leather dressing, consisting of beeswax, neat's foot oil, drop black, heel ball and molasses.

432,861.—Process of fermenting. E. Carez.

The development of injurious and destructive ferments in the manufacture of syrups, sugar or alcohol, is prevented by subjecting the wort of amylaceous substances to the action of hydrofluoric acid.

432,926.—Process of making acetic acid. I. A. T. Bang and M. C. A. Ruffin.

A hot solution of calcium acetate is decomposed with hot sulphuric acid.

432,939.—Apparatus for manufacturing wood gas. J. Hanlon.

(*Issued July 29th, 1890.*)

432,989.—Blue dye. C. Duisberg.

Produced by the action of the tetrazo compound of benzidinesulphonedisulpho acid upon phenylbetanaphthylamine. In the dry state it is an indigo blue, amorphous powder, difficultly soluble in cold water, easily soluble in hot water and alcohol, insoluble in benzol. In concentrated sulphuric acid it dissolves with red violet color. It dyes unmordanted cotton in alkaline bath, and wool and silk in a neutral bath with a fine indigo blue shade.

433,066.—Process of making soap. J. B. N. Berry.

Pine needles are treated with an alkaline solution to extract the resin, after which the fatty materials are added to the solution and saponified.

433,074.—Art of silvering mirrors. A. B. Drautz.

A solution for silvering mirrors consisting of ammoniacal silver nitrate, sodium and potassium tartrate, milk sugar, silver sulphate, a lead salt, sulphuric acid and water.

433,086.—Process of deoxidizing copper. W. W. Keys.

Copper and its alloys are deoxidized and purified by melting the metal by exposure to the hot products of combustion developed by burning hydrocarbon oils, then raising the molten metal to a high temperature, and then while practically excluding atmospheric oxygen further exposing the metal to the flaming products of combustion afforded by the oil.

433,119.—Process of making potash soap. H. Eurich.

A strong solution of caustic potash is added to a fat, and the mixture kept at a high heat until a product is obtained, which on cooling is a hard potash soap.

433,126.—Gas purifier. J. Hearne.

433,129.—Process of manufacturing and in the composition of refractory cements. W. S. Lea.

The process consists of the following steps : Disintegrating materials whose chemical composition is chiefly that of a compound silicate of alumina and of alkalies and earthy bases, mixed with quartz by subjecting the same to the simultaneous action of heat and vapors of nitric and hydrochloric acids, reducing the disintegrated materials and mixing therewith silicious materials whose composition is chiefly hydrated silicate of

alumina, together with calcium phosphate and carbonate, caustic potash and manganese, again reducing the compound and mixing therewith sodium chloride and an alkaline silicate.

433,131.—Process of ageing wine. G. H. Malter.

Consists in passing the wine through vapors produced by heating another wine.

433,135.—Apparatus for decomposing metallic salts. O. B. Peck.

433,152.—Extracting fats and oils. M. Schroeder.

The materials containing fats and oils are subjected to the elutriating action of sulphurous acid, after which the sulphurous acid is removed by distillation and condensation.

433,185.—Dental vulcanizer. J. E. Quinn.

433,215.—Insulating compound. I. Rabinowicz.

Consists of tartaric acid, a tartrate, gilsonite and palm stearin pitch.

433,326.—Process of preparing wood pulp. W. N. Cornell.

433,336.—Apparatus for oxygenating and carbureting air. C. Fiesse.

433,341.—Regenerative gas lamp. E. Tullford.

433,395.—Obtaining pepsin. J. Brill.

The process consists in, first, finely chopping hogs' stomachs; second, subjecting the prepared mass to the action of acid and water, and heating it for about three hours; third, pressing the juice from the mass; fourth, clarifying the juice by a benzine bath, and then drying the precipitated pepsin.

(*Issued August 5th, 1890.*)

433,455.—Solidified perfume. G. H. Dubelle.

Consists of paraffin intimately mixed with powdered orris root and a volatile perfume.

433,495.—Carburetor. A. B. Smith.

433,534.—Apparatus for washing the fumes of sulphur. T. W. Montgomery and J. Warnke.

433,537.—Glass tube cutter. T. McGar.

433,603.—Regeneaative furnace. S. R. Smythe.

433,604.—Regenerative furnace. S. R. Smythe.

433,653.—Lump fuel of coal, charcoal or coke screenings. A. Mayer.

A lump or block fuel, composed of coal, coke or charcoal screenings or dust, a glutinous substance, an oleaginous substance, a plastic substance, and a fibrous substance combined with silicate of soda.

433,729.—Process of manufacturing butter. G. H. Hamrick.

The raising of cream from milk is effected by the action of sulphurous acid gas.

433,784.—Process and apparatus for manufacturing, heating and illuminating gas. C. F. Hadley.

The process consists in burning fluid hydrocarbon in conjunction with

air and steam, then condensing and eliminating the aqueous vapor from the gaseous product, and then reheating the product in conjuction with fluid hydrocarbon.

433,790.—Process of dyeing. T. Ingham.

A process of dyeing woven or knitted fabrics of mixed animal and vegetable fibres (such as yarns woven together in the gray state), consisting in first submitting the mixed fabric to a bath of the required coloring matter or solution without any mordant; second, dyeing the fabric; third, oxidizing the coloring material on the dried fabric by passing the same through a solution having the property of fixing the colors both upon the vegetable and animal fibres at one and the same time.

433,802.—Apparatus for the manufacture of gas. K. M. Mitchell.

433,861.—Composition of matter for plaster. De L. Haigh.

A compound for admixture with lime, etc., in the formation of plaster, consisting of fine silicious material coated with a soluble sulphate and borax.

433,877.—Disinfectant. W. F. Simes.

Consists of naphthalene, oil of camphor, and caustic soda.

433,890.—Process of purifying water. P. Degener.

Organic impurities are precipitated by adding magnesium carbonate, then lime or its equivalent is added to precipitate the magnesia, and finally, a chemical, such as carbon dioxide is added, to precipitate the excess of the precipitant.

433,893.—Insulating material. J. Tottrell.

Consists of a mixture of india rubber and aluminium.

433,899.—Artificial plaster. H. Leichsenring.

Consists of glycolline, plaster of paris, water and coloring matter.

433,926.—Apparatus for the manufacture of gas. J. B. Archer.

(*Issued August 12th, 1890.*)

434,016.—Antifriction compound. H. B. Devlan.

Consists of bamboo fiber, paper pulp, asbestus, plumbago, and a sizing, such as sodium silicate.

434,039.—Explosive compound. H. S. Maxim.

The process of manufacturing consists in mixing and agitating pyroxyline or gun cotton with a compound of nitroglycerin, castor oil, and a proportion of a solvent, such as acetone, insufficient to dissolve the entire gun cotton, then subjecting the product in a partial vacuum to the action of acetone, and then to pressure.

434,074.—Process of sugar refining. L. Sternberg.

An improvement in the art of refining low grade sugars, molasses, syrups, or vegetable juices, consisting, first, in boiling the saccharine solution with a suitable quantity of lime, or its equivalent, thereby decomposing the glucose present, and then separating the resulting insoluble

glucose compounds by filtration; and, secondly, in treating the remaining solution with acid, and precipitating and removing by a second filtration the resulting lime compounds and the remaining impurities present, preparatory to subjecting the solution thus freed from glucose and injurious compounds resulting from the decomposing of the glucose to further treatment for the extraction of the crystallizable sugar.

434,184.—Furnace for melting glass. L. Houze.

434,243.—Combined fertilizer and insecticide. L. J. Carlile and G. B. Rumph.

Consists of refuse tobacco, bran, cotton seed meal, paris green, powdered hellebore, arsenious oxide and India berries.

434,287.—Process of manufacturing nitrocellulose. G. M. Mowbray.

434,288.—Machine for the continuous manufacture of nitrocellulose. G. M. Mowbray.

434,296.—Flux or solution for coating metals. B. S. Richardson.

A solution for the preparation of iron for coating it with lead, consisting of zinc chloride, oxalic acid, ammonium chloride, and sodium sulphite.

434,330.—Varnish. W. D. Field.

Consists of saturated solutions of pyroxyline and resins or gum resins in suitable solvents.

Issued August 19th, 1890.

434,490.—Composition of matter for mortar. M. Furley, G. W. Chamberlin and P. M. Pomeroy.

Consists of ashes, sand, marble dust, plaster of paris, shorts, and sugar or other saccharine matter.

434,493.—Blue dye. A. Weinberg.

Has the chemical constitution of a disulphonated tertiary dibenzyl derivative of thionine, and shows the following characteristics: it is easily soluble in water with a bright blue color, less soluble in alcohol, insoluble in ether; it dissolves in strong sulphuric acid with a green color, which is changed into blue by addition of water; by reducing agents it is transformed into leucosulpho acid. It dyes animal fibre in an acid bath a greenish blue.

434,502.—Muffle furnace for desulphurizing ores. G. H. Chick.

434,556.—Fireproof paint. J. T. Durkee.

Consists of gas tar, asbestus and clay.

434,569.—Plastering composition. W. Robinson.

Consists of sawdust saturated with a solution of quicklime, alum, and white lead with plaster of paris, glue and sand.

434,570.—Filter. W. H. Sargent.

434,471.—Filter. W. H. Sargent.

434,621.—Apparatus for the manufacture of gas. J. B. Archer.

434,623.—Process of making white lead. A. C. Bradley.

Consists in subjecting a solution of the basic acetate of lead containing between 10 and 12 per cent. of the basic acetate in a slowly moving thin sheet to the joint action of heat of about 120° F and carbon dioxide.

434,645.—Process of treating hides. J. Schmitt.

The process consists in coating the fleshy side of the hides with a warm solution of fresh slaked lime and water while the hair is on the hides, and then piling them one upon the other with the hairy side down and allowing them to remain in this condition from half an hour to an hour, this step in the process serving to raise the hides and increase the thickness thereof, and preceding the usual steps of the depilating lime bath.

434,666.—Water purifying apparatus. O. H. Jewell and W. M. Jewell.

434,694.—Process of reducing iron ores with heated gases. C. Adams.

434,696.—Process of extracting oil. C. F. Binder.

Consists in subjecting the material from which the oil is to be extracted to direct contact with superheated or dry steam of such a high temperature that only sufficient moisture is applied to the material to take the place of the oil in the cells, and then expressing the oil.

434,739.—Method of manufacturing articles for containing petroleum. H. Thame.

Vessels, pipes and other receptacles are made by saturating or impregnating a bibulous paper with a solution of shellac, and then wrapping it layer upon layer to the thickness required, the layers being united by interposed films of shellac.

434,790.—Stove polish. S. A. Kingsland.

Consists of water, borax, shellac, wax and burned cork.

434,798.—Paint. J. G. W. Mastens.

Consists of water, bone black, charcoal, red lead, boiled linseed oil and saltpetre.

434,831.—Filter press. F. Kleemann.

(*Issued August 26th, 1890.*)

434,941.—Gas washer. W. Morava.

434,948.—Mixer for natural gas. A. A. Phillips.

434,977.—Process of preparing fertilizers. C. Clifford.

Refuse leather is dampened and placed in heaps to sweat or ferment, after which the heaps are opened and exposed to the air. These operations are repeated as long as the fermentation continues, and the resulting product is ground or passed through sieves.

435,000.—Apparatus for cooling and aerating wort for malt liquors. C. D. Stanford.

435,009.—Apparatus for burning hydrocarbon oils. J. H. Bullard and F. A. Nickerson.

435,050.—Composition of manganese and iron for brake shoes. W. W. Snow.

An alloy containing 5 to 15 per cent. manganese.

435,070.—Apparatus for the manufacture of illuminating gas. P. W. Mackenzie.

435,071.—Process of manufacturing illuminating gas. P. W. Mackenzie.

The process consists in evaporating hydrocarbon oil, mixing the products of evaporation with the products of combustion of hydrocarbon oil, steam and oxygen or air, conveying away the gaseous products resulting therefrom and fixing them, employing the fixed gas to evaporate the hydrocarbon oil and conveying away the heavy unevaporated oil and residual products at different levels below the oil being evaporated.

435,076.—Artificial fuel. A. Pagenstecher.

Consists of pulverized coal, charcoal or coke, and starch, saltpetre, and brown sandstone.

435,096.—Funnel. H. W. Hoops.

The bell of the funnel is provided with undercut ribs.

435,129.—Process of crystalizing soda alum. E. Augé.

A solution of aluminium and sodium sulphates is concentrated to a specific gravity of between 1.32 and 1.42 and cooled until it assumes a pasty consistency. The paste is then exposed in layers, upon inclined surfaces, to a temperature between 15 and 20° C. till the mother liquors are separated, whereby crystals of uniform composition and size are obtained.

435,198.—Process of refining crude asphaltum. R. Alexander.

The process consists in dessicating crude asphaltum, recovering the condensable oil given off during the desiccation, and subsequently returning said oils to the desiccated material.

435,269.—Apparatus for burning hydrocarbons. J. H. Bullard.

435,270.—Hydrocarbon burning apparatus. J. H. Bullard.

435,280.—Process of making ammonium nitrate. E. Carey.

Barium sulphate is calcined out of contact with air with a mixture of charcoal and resin oil (or other hydrocarbon), and the product of the reaction boiled with sulphur and water to produce a polysulphide. This is then converted into barium nitrate by means of sodium nitrate. The crystalized barium nitrate is finally decomposed with ammonium sulphate.

(*Issued September 2d, 1890.*)

435,421.—Battery compound. E. M. G. Hewett.

Consists of chromic oxide and ammonium chloride dissolved in water and combined with sulphuric acid or its equivalent.

435,464.—Ammonia still. G. Stroh and G. Osius.

435,485.—Composition of matter for artificial stone. J. Elliott.

Consists of Kentish rag, Portland or York stone, finely sifted Bath stone dust and water mixed with Portland cement.

435,509.—Insecticide. W. Mann.

Consists of flowers of smart weed, lime and sulphur.

435,670.—Regenerative gas burner. F. Stellwag.

435,720.—Apparatus for the manufacture of gas. J. B. Archer.

435,747.—Diffusion apparatus. L. F. Haubtman.

435,760.—Apparatus for galvanizing. C. E. Matteson.

435,784.—Apparatus for the treatment of cane juice. J. J. Adams and L. W. Tracy.

435,856.—Carburetor. L. C. Parker.

435,862.—Process of making carbon tetrachloride. E. G. Scott.

The process consists in passing dry chlorine gas slowly through carbon bisulphide and iodine, separating the carbon bisulphide and carbon tetrachloride, which is formed from the sulphur chloride by distillation, then fractioning the tetrachloride and treating it with caustic alkali to remove the iodine. The concentrated aqeous solution of iodine is treated with a strong mineral acid and chlorine to set free the iodine. This is extracted with carbon bisulphide and the solution is used in the first step of the process.

435,911.—Preserving compound. O. Williams.

Consists of ground coffee berries, ground cinchona bark and ground cinnamon mixed with flowers of sulphur, pulverized sugar and pulverized potassium nitrate.

(*Issued September 9th, 1890.*)

435,922.—Process of tanning hides. T. L. Crafton.

The process consists in first immersing the hides in a mixture consisting of fifteen gallons of water, six quarts slaked lime, six quarts ashes and one pound of soda; second, removing the lime from the hides by immersing them in a bath consisting of twenty gallons salt water, one peck of wheat bran, two gallons of buttermilk, half pound of acetic acid (6%) or strong vinegar, and three pounds of salt; third, submerging then in a tan ooze consisting of fifteen gallons of water, ten pounds of gambier, four pounds of salt, three pounds of saltpetre and one pound of acetic acid (6%) or strong vinegar.

435,940.—Compound for converting wrought iron into steel. W. J. Miles, Jr.

Consists of potassium ferrocyanide, glycerrhizinum ammoniatum, and ammoniacum.

436,029.—Apparatus for charging inclined gas retorts. L. VanVestrant.

436,044.—Filtering apparatus, R. E. Miller.

436,133.—Process of separating fats from emulsions. C. D. Hellström.

The emulsions are subjected simultaneously to centrifugal force and to temporary accellerations parallel or nearly so with the axis on which the centrifugal force is generated.

436,199.—Percolator. W. D. Warwick and C. E. Cunningham.

436,225.—Insulator. J. C. Firth.

Consists of pumice stone.

436,227.—Apparatus for extracting oils with the acid of solvents. W. T. Forbes.

436,244.—Method of and apparatus for the production of mineral wool. W. H. Kennedy.

436,250.—Substitute for iodoform. J. Messinger and G. Vortmann.

A red brown odorless powder derived from iodine and salicylic acid, which is insoluble in water, alcohol, ether, and oil, changing to a bright red powder by heating it with mineral acids and melting at about 225° C., with decomposition, and being insoluble in alkalies.

(Issued September 16th, 1890.)

436,414.—Tower for condensing acid. C. Graham.

436,497.—Steel alloy. R. Hadfield.

Contains chromium, together with manganese and silicon.

436,534.—Process of manufacturing beer. A. J. Metzler.

Consists in maintaining the beer under a partial vacuum during the ruh stage until it has ripened, then adding a small proportion of saccharine matter, and permitting the carbonic acid gas developed to relieve the vacuum in the cask and beer.

436,535.—Process of making beer. A. J. Metzler.

436,536.—Process of manufacturing beer. A. J. Metzler.

436,537.—Process of preparing ruh beer for market. A. J. Metzler.

436,587.—Process of producing photographic films. J. Schwartz.

The sensitiveness to light is increased by treating the film with formaldehyde.

436,599.—Composition for making fabrics fireproof. R. R. Graf.

Consists of ammonium sulphate, ammonium phosphate, ammonium chloride, lime, sodium tungstate, and water.

436,623.—Apparatus for making extracts. G. S. Andres.

436,624.—Apparatus for making extracts. G. S. Andres.

436,633.—Process of purifying brines. M. M. Monsanto.

Uses trisodium phosphate.

436,684.—Apparatus for and process of continuous rectification of spirits, alcohol, etc. E. A. Barbet.

436,733.—Insulating material. J. W. Easton.

Consists of soapstone, waterproofing material and a fibrous substance.

436,735.—Process of and apparatus for manufacturing alcohol. G. Gingnard and A. Hédouin.

436,764.—Process of and apparatus for rectifying and distilling alcohol. E. A. Barbet.

(*Issued September 23d, 1890.*)

436,812.—Apparatus for making hydrogen gas. J. W. Tallmadge.

436,881.—Apparatus for the manufacture of oil gas. D. E. Teal.

436,882.—Apparatus for making coke and gas. C. N. Trump.

436,895.—Process of electro-depositing aluminium. J. A. Jeançon.

Consists in subjecting a supersaturated solution of an oxysalt of aluminium in water to the action of an electrolytic current passed through the electrolyte between an anode plate of aluminium in a state of division or porosity, and a suitable metallic cathode to be plated.

436,898.—Manufacture of explosives. H. S. Maxim.

Consists in confining gun cotton in a receiver, exhausting the air from the same, then introducing a vaporized solvent into the exhausted receiver until the gun cotton is partially dissolved, then compressing it, and then dividing it up into small pieces or grains.

436,975.—Gas generator. C. W. Gibson.

436,994.—Standpipe for ammonia gas generators. M. Poschinger and H. Vogt.

437,098.—Gas producer. J. W. Culmer.

437,136.—Gas machine. J. S. Wood.

437,140.—Process of calcining gypsum. J. Sickler.

437,163.—Process of manufacturing artificial fuel. W. B. McClure.

437,164.—Artificial fuel. W. B. McClure.

Consists of pulverized culm or coal dust, sand, calcined lime dust, and solid and naturally liquid asphaltums. W. R.

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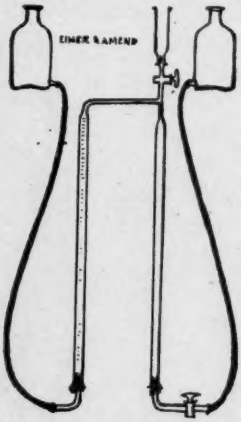

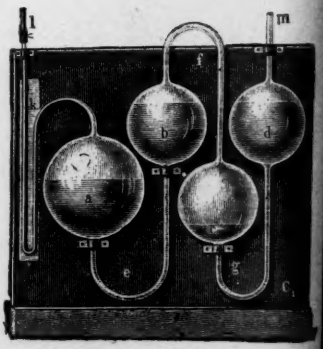

PURE HAMMERED PLATINUM WARE,

Best Bohemian and German Glassware,
Royal Berlin and Meissen Porcelain Goods,
Analytical Balances and Weights.

Sole Agents for

Schleicher & Schull's Celebrated Filter Papers, Scheibler's Polariscopes, Jolly's Balances,
Schmidt & Haench's Optical Goods,
F. & M. Lautenschlaeger's Bacterioscopical Apparatus,
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